Time is Not Malleable

A new perspective on relativity—preserving the math and evidence, while rethinking whether time truly stretches or space actually shrinks.

Kamel Alboaouh

Copyright © 2025 by Kamel Alboaouh

All rights reserved.

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without the prior written permission of the author, except in the case of brief quotations used in reviews or scholarly works.

This book is a work of non-fiction. While every effort has been made to ensure accuracy, the views and interpretations presented are those of the author.

Published by Kamel Alboaouh

Printed in the United States of America

ISBN 979-8-292-37500-5

Second paperback edition, 2025

1 PREFACE

This book is part of my ongoing journey to understand time—a journey that began as a personal inquiry and gradually deepened into a serious reassessment of one of modern physics' most influential theories: the theory of relativity. What started as a desire to simply grasp how time works led me to confront the very foundations of how science describes it.

As I explored the nature of time, I encountered an unexpected tension. Relativity stands out as a conceptual outlier: it reshapes our perception of time in ways that conflict with long-standing human intuition. At first, I had no intention of challenging Einstein's theory. My only aim was to understand it. But the more I delved into its premises and empirical basis, the more I became convinced that the theory's treatment of time warranted a fresh interpretation—one that remained consistent with experimental evidence but did not require time to slow down or space to contract.

To be clear, I am not refuting relativity. Rather, I am reinterpreting it. This reinterpretation is not speculative; it is grounded in the same body of empirical data traditionally cited to support relativity. Through careful analysis, I found that these experiments can be understood just as well—if not more coherently—within an alternative framework, one that preserves the integrity of the data without invoking effects like time dilation or length contraction.

The original version of this book was a short paper, just eight pages long. I submitted it to a peer-reviewed journal, hoping to start a scientific dialogue. It was rejected. At the time, I thought the rejection might stem from methodological issues, so I worked to refine my argument. But as I continued engaging with the physics community, I realized the difficulty ran deeper. Physicists, like most humans, do not easily change their views—especially when the prevailing framework

has been long accepted. History offers many examples of this resistance to change. This resistance creates a dilemma. If new ideas struggle to gain attention, where can dialogue happen? Peer-reviewed journals, rather than providing a platform for open discussion, often serve as a wall protecting mainstream interpretations. To overcome this, I decided to transform my paper into a book—one that could reach a wider audience and present the ideas in a more accessible, transparent, and complete form.

That decision was crucial to me because I no longer seek validation from gatekeepers. I welcome critique—especially thoughtful, constructive engagement. Unfortunately, most of the responses I've received from physicists have been dismissive—relying on evidence that, in my view, did not adequately support their rejection and often lacked the depth of analysis one would expect in a serious scientific critique. This kind of dismissal risks encouraging a culture of intellectual complacency, where claims are rejected reflexively rather than examined with care. Some of them , for instance, demand new experiments, seemingly unaware that my work is built upon the very same experiments they trust.

Some have accused my reasoning of being "philosophical"—a characterization that reveals a misunderstanding of both my work and the nature of philosophy itself. There is nothing speculative or abstract about my approach; I reinterpret the same data, experiments, and mathematical models used by physicists. That makes this work scientific by definition, not philosophical. My approach is grounded in the interpretation of empirical data, just as Einstein's 1905 paper was. I do not speculate—I rethink.

This second edition of the book introduces several improvements. Most importantly, I've divided the content into two sections: one presents my reinterpretation in scientific language for physicists, while the other explains the same ideas in plain language, making them

accessible to readers without a background in math or physics. I've clarified key points, revised sections for greater readability, and corrected typographical errors. In addition, I've proposed an experimental setup to test the core idea of the reinterpretation—offering a concrete way to verify this alternative view of spacetime.

This book is not a call to reject established theory, but an invitation to look again—carefully, openly, and logically—at evidence we think we already understand. It is a call to curiosity, and a reminder that even our most trusted theories must be open to reexamination.

I would also like to extend my special thanks to the tools that made the writing of this book possible. Without them, this work might have remained an idea in my head. I am especially indebted to Google, ChatGPT, and DeepSeek, whose support made the process far easier than I ever anticipated. They assisted me in polishing my English, paraphrasing sentences, suggesting analogies, and—most importantly—helping me access relevant information quickly. That said, the ideas and interpretations presented in this book are entirely my own. The role of artificial intelligence was limited to helping express and support my thoughts—not to generate them. Moreover, any scientific or historical information cited in this book has been verified directly from its original source to ensure accuracy. If any error remains, it is solely my responsibility and may stem from my own misunderstanding—not from the tools I used.

Kamel Alboaouh,

July 2025.

Kamel.alboaouh@hotmail.com

CONTENTS

1 Preface II
2 Introduction 1
3 Part A: For Readers Without a Physics Background 7
3.1 The beginning 8
3.2 Light constant speed! what does that mean? 10
3.3 My two cents on light 11
3.4 Beyond Light: Reinterpreting Motion for Massive Objects 16
3.5 Gravity and spacetime 19
3.6 Empirical evidence 26
4 Part B: Special Relativity. 48
4.1 Preliminary distinction 50
4.2 Lorentz Transformation 55
4.2.1 Lorentz Transformation 55
4.2.2 Proper Time Invariance 59
4.3 objects with mass at High speed 60
5 Part C: General Relativity 64
5.1 Curvature of spacetime. 67
5.2 Time 75
5.2.1 Gravitational Redshift 75
5.2.2 Viking Signal Delay (Shapiro Delay) 81
5.2.3 Gravitational Time Dilation 83
5.2.4 Relativistic time dilation 85
5.3 Space 88

5.3.1 Starlight Bending 88
5.3.2 Gravitational Lensing 90
5.4 Mass and gravity 93
5.4.1 Orbital Decay 94
5.4.2 Periastron Advance 96
5.4.3 Frame Dragging and Spin Precession 99
5.5 Mass and energy 101
5.5.1 Mass-Energy Inference 102
5.5.2 Orbital Inclination and Geometry Effects 104
5.6 Summary: Mass, Energy, Gravity, Acceleration, and Spacetime 108
6 Part D: Experiments, revisited 109
6.1 Viking Relativity Experiment. 110
6.2 GPS Timing 113
6.3 Double pulsar experiment 117
6.4 Li^+ 123
6.5 Muon Experiment 127
6.6 Hafele and Keating experiment 132
6.7 Gravity Probe A (GP-A) mission experiment 136
6.8 Pound and Rebka Experiment 140
7 Proposed Experiment 146
7.1 Addressing the "Philosophical" Criticism 146
7.2 Designing a Test for This Reinterpretation 146
8 Interpretations Summary 153
9 References 161

2 INTRODUCTION

Imagine a man who arrives earlier than expected at his destination. You ask him, "How did you get here so quickly?" His answer is simple: "I drove faster."

And of course, that makes sense. He sped up—so he arrived sooner. The road didn't suddenly get shorter. Time didn't stretch. He simply moved faster. Case closed... or is it? Let's pause and look at this situation from another angle. Let's express it with an equation:

Speed = Distance / Time

This mathematical model allows us to describe the man's early arrival in three different—but equally valid—ways:

- He increased his speed.
- The road shrank.
- Time stretched.

Mathematically, they're all acceptable solutions. The equation doesn't care which variable changes—it simply balances. But that's the point: **math doesn't think, choose, or explain.** It only describes. It's a tool—one that obeys structure but doesn't provide meaning. Interpretation is a human task.

So why do we say the man sped up, and not that the road shrank or that time expanded? Because as physical beings living in a physical world, we rely on natural intuition and experience to decide what's reasonable. We interpret the math—we don't

follow it blindly. This distinction—between what math allows and what nature permits—is the beating heart of this book.

In what follows, I will argue that while the mathematical framework and measurements of relativity are correct, the common interpretation—that time dilates and space contracts—is not the only explanation. I do not refute the theory of relativity. Instead, I propose a **reinterpretation** of it. One that keeps the equations intact, respects the experimental evidence, but questions the idea that time and space themselves are malleable.

This book invites you to rethink what might be the most accepted assumption in modern physics: that spacetime deforms. What if it doesn't? What if the universe is not as flexible as it seems—but instead, it's our understanding that has been stretched?

Over the past century, the theory of relativity has been tested again and again [1]—and it has passed with extraordinary precision. The bending of light around massive objects, the ticking of atomic clocks in orbit, the behavior of particles in accelerators, and the astonishing confirmation of gravitational waves—these all speak to the predictive power of relativity. This success has made relativity more than just a theory—it has become a lens through which we view the nature of reality. It has shaped cosmology and the very language of modern physics. Space and time, once thought to be separate and absolute, are now seen as interwoven and elastic—spacetime. And yet, I find myself asking a simple question: **Could we have misunderstood what's really changing?**

The central claim of this book is simple: time and space do not physically deform. The equations and observations of relativity are valid—but the way we interpret them may not be. Effects like time dilation and length contraction, I argue, are not literal distortions of reality, but mathematical adjustments—reflections of how our models must behave to preserve the constancy of light's speed.

Challenging that interpretation is no small task. Relativity stands on a century of textbooks, experiments, and deeply rooted assumptions. To question its interpretation—even without changing its mathematics—requires revisiting much of modern physics from a different perspective. This book undertakes that task by reexamining key experiments long thought to prove spacetime deformation, and showing how the same results can be understood through a new lens.

Now, let me address a common point of confusion. When I refer to time dilation or length contraction as "mathematical artifacts," I am not calling them fictitious or imaginary. This is a crucial distinction. In mathematics, a fictitious (or dummy) variable is one that lacks physical meaning—like adding "X − X" to an equation, or a variable inside an integral that vanishes after evaluation; These serve symbolic purposes only and represent nothing in the real world. Time dilation is not that. It is measurable and well-documented—in satellites, particle decay, and atomic clocks. But while the effect is real, its physical meaning is not as settled as it may seem. I argue that time dilation arises not because time itself stretches, but because our equations adjust in order to preserve the constancy of light's

speed. It's a real outcome of our models—but not necessarily a deformation of time itself.

Also, when I say that time and space don't deform, I'm not suggesting that deformation is an illusion or that we are misperceiving reality. The question I'm asking is deeper: What is actually changing in reality when a mathematical variable changes in the theory of relativity? In other words, I invite the reader to consider this: What if spacetime deformation in relativity isn't the result of time stretching or space contracting, but rather a consequence of how we've constructed our equations to preserve the constancy of light's speed? That is the heart of this book's proposal.

➢ Book outline

This book is divided into four main parts following the introduction, each serving a different purpose and audience:

- **Part A: For Readers Without a Physics Background**

This section is written in plain language and uses analogies and clear, step-by-step reasoning. It introduces the key concepts and offers a full explanation of the reinterpretation of relativity without requiring any background in physics or mathematics. If you only read Part A, you won't miss anything essential—it contains the complete conceptual picture.

- **Part B: For Physicists**

This part is designed for readers familiar with physics and mathematics. The section is carefully structured around key

themes: a reanalysis of special relativity, a theoretical treatment of the Lorentz transformation, and an extension of the reinterpretation to massive objects. It maintains all standard mathematical formulations but offers an alternative interpretation that does not require time or space to physically deform.

- **Part C: General Relativity**

Here, the focus shifts to general relativity. This section reinterprets gravitational phenomena—such as spacetime curvature, time dilation, and gravitational redshift—through the lens of acceleration and physical fields, rather than spacetime deformation. It retains the mathematical structure of Einstein's equations but offers a different physical interpretation.

- **Part D: Experiments, Revisited**

This final part revisits key experiments often cited as proof of spacetime deformation—including the Viking experiment, GPS, the double pulsar, lithium-ion decay, and others. Each experiment is reexamined using the interpretive framework developed throughout the book. The goal is to show that the same results can be explained through physical field interaction and structured acceleration without assuming that time or space physically stretch.

- **Summary of Interpretations**

Before the book closes, this summary chapter consolidates the reinterpretations introduced throughout the book. It brings together the key conclusions from Parts A through D, offering

readers a clear, concise reference to the full reinterpretive framework. This chapter is especially useful for reviewing the central claims without rereading the entire book. However, this summary chapter is not written for general audience. The book, also, closes with a concrete step forward: a proposed experiment designed to test whether the reinterpretation of relativity offered in this book holds up in practice. This chapter presents an idea for how to distinguish between the standard interpretation and the alternative view using modern technology. It offers a way to move the discussion from theory and interpretation into testable science.

Together, these parts form a coherent argument: that relativity's mathematics and measurements are correct, but our common interpretation—that space and time physically deform—may not be necessary. The book keeps the tools of physics intact, but offers a new way to understand what those tools are describing.

3 PART A: FOR READERS WITHOUT A PHYSICS BACKGROUND

This part of the book is dedicated to all readers who are curious about the nature of time and space—but who may not feel comfortable with mathematical language or advanced physics. If equations make your eyes glaze over, or if you've ever felt lost in a conversation about relativity, this section is for you.

Here, I explain the core ideas behind my reinterpretation of spacetime using simple language, familiar analogies, and step-by-step reasoning. No prior background in physics is required. My goal is to make the concepts accessible and meaningful—because the questions we're dealing with are not just for physicists. They're for anyone who has ever wondered: *What is time, really? What do we mean when we say it stretches or contracts?*

You will not find formulas in this section. You will not need to solve anything or follow technical derivations. Instead, I'll walk you through the logic, the experiments, and the reasoning that led me to challenge the common interpretation of relativity—specifically, the idea that space and time physically deform.

This section is not a simplified summary. It's a full explanation written in plain language. It covers the same material as Part B of the book, which is intended for readers with a technical background. So, if you read only this part, you will still come away with the complete picture of what I'm proposing—and why it matters.

3.1 The beginning

A long time ago, physicists believed that everything needed a medium to travel through. Sound needs air. Vibrations need a solid object. So they wondered: what about light?

Light is a wave, but unlike sound, it doesn't need air. It doesn't need solids or liquids either. It can travel through empty space—like the vast distance between Earth and the Sun. That was puzzling. Every other wave they knew required something to move through. Light seemed to break that rule.

To solve this mystery, scientists proposed something invisible: the *luminiferous ether*. They imagined this substance filled all of space and gave light something to "ride on."

There was another reason they liked the ether—it provided a frame of reference. Just like you can't say how fast a car is going without knowing what it's moving *relative to*, physicists needed something to measure light's speed against.

For example, if you're driving at 100 mph, a police officer standing still might report that exact speed. But an officer driving 30 mph in the same direction might say you're only going 70 mph. Who's right? It depends on their frame of reference.

Physicists thought the ether served that role for light – being a frame of reference. It gave the physicists a universal reference point. So, naturally, they believed it must be real.

In 1887, Albert Michelson and Edward Morley set out to test the idea of Ether. If Earth moves through the ether, then

light moving "with" that flow should travel slightly faster than light moving across it—just like walking with or against the wind. They built a clever experiment to measure the difference.

But to everyone's surprise, there was **no** difference. The speed of light stayed the same in all directions. No matter how they turned the experiment, the light beams always returned at the same time.

The conclusion? **There was no detectable ether.**

This result was shocking. But years later, it helped inspire Albert Einstein's *special relativity*. He proposed that light doesn't need a medium at all, and its speed is always the same—no matter how fast the observer is moving. He went even further: there's no need for an absolute frame of reference at all. Everything can be measured *relatively*.

So what's the big lesson from the Michelson–Morley experiment? **The speed of light is constant for all observers.**

Let's explore why this matters with an example.

Imagine two people. One is sitting in a chair on the side of the road. The other is driving north at speed of 1 million miles per hour.

Now imagine two things moving north:

- A beam of light traveling at speed of 7 million mph
- A bullet traveling at 3 million mph

The person in the chair sees the light is travelling at 7 million mph and the bullet at speed of 3 million mph.

The person in the car sees the bullet is travelling at only 2 million mph (because they're already moving at 1 million). But surprisingly, they still see the light moving at **7 million mph**, not 6. That's the mystery.

The lesson from above example is to tell you that *light behaves differently*. Its speed doesn't change based on your motion. No matter who you are or how fast you're going, light always moves at the same speed with respect to you.

3.2 Light constant speed! what does that mean?

The idea that light's speed is the same for everyone—regardless of their own motion—changed physics forever. But it also raised a puzzling question: *How can the speed of light be constant for all observers, no matter how fast they're moving?*

To understand why this matters so much, let's start with a simple question: What is speed? It's the distance you travel over a period of time. For example, if you move 10 miles in one hour, your speed is 10 miles per hour.

Now imagine something strange happens: *space shrinks*. What used to be 10 miles now appears to be 20. But if your speed is still measured as 10 mph, then you must be covering that 20 miles in just one hour. To some observers, it would look like you're moving faster—even though you're not doing anything differently.

Now imagine a different twist: *time stretches*. What feels like one hour to you might feel like two hours to someone else. So, if you travel 10 miles—but someone else sees that journey taking two hours—they'd conclude your speed was only 5 miles per hour.

Here's the key idea:

If the speed of light is to remain constant for everyone, then something else has to give; Either space must shrink, or time must stretch—or both.

This is exactly what the Michelson–Morley experiment hinted at. Even when scientists expected light's speed to change, it remained constant. That unexpected result demanded a new explanation. Later, physicists like Lorentz and Einstein offered one: *space and time are not fixed. They stretch or shrink depending on how fast you're moving*.

That simple explanation —but radical—became the foundation of modern physics. It changed everything about how we understand motion, time, and reality itself.

3.3 My two cents on light

However, there's still something that feels a bit unsettling. **Time stretching** and **space shrinking** are not easy ideas to picture. So, I decided to explore this explanation more deeply—just as scientists once did.

When I studied this topic, I arrived at a different interpretation—one that's much simpler and fits better with

how we naturally perceive the world. So, here's my alternative explanation.

But before I share it, let's first describe more precisely what's happening with light. Saying *"the speed of light is the same for all observers"* is true, but a more accurate way to say it is:

"**The speed of light is independent of the speed of its source**."

This rewording is important, because it helps us avoid being led down the wrong path in our reasoning. Now, let me explain that with a simple example.

Imagine a **flashlight** and a **gun** are both moving at **1 million miles per hour**. At the same moment, the flashlight emits a beam of light, and the gun fires a bullet—both in the same direction.

Let's ask:

- What would be the speed of the light and the bullet as seen by a **stationary observer**?
- By the **flashlight**?
- And by the **gun**?

Let's assume the stationary observer measures both the light and the bullet to be traveling at **7 million miles per hour**.

Then, From that the stationary observer's point of view:

- The **bullet** is affected by the motion of its source. So, relative to the gun, the bullet is moving at **6 million mph**.
- But the **light** behaves differently. So, both of the flashlight and the gun still measure the light speed to be **7 million mph**.

Why light speed has not changed to all observers? Because the speed of light **does not depend** on how fast its source is moving, and this is where everyone agrees, no dispute at all. However, the physicists had to describe this strange behavior of light mathematically. And every time they tried, they found themselves **adjusting space and time** mathematically in their equations just to make the numbers work. To keep light's speed constant in all frames, either **distances must shrink** or **time must stretch**—or both. Thus, the scientists interpreted of mathematical adjustments are quite literally. They concluded that **space actually shrinks** and **time really stretches** when objects move at high speeds.

Personally, I disagree with that interpretation. I see these changes not as actual distortions of reality, but as **mathematical adjustments**—tools we use to describe how light behaves. In other words, what we call the "stretching" of time or the "shrinking" of space reflects how our mathematical framework is forced to adapt in order to describe what light is doing in the real world. These adjustments are not arbitrary—they're a direct response to the physical fact that the speed of light remains constant for all observers. This doesn't necessarily mean that space and time are literally deforming, as if they were rubber sheets twisting and warping in some physical medium.

Rather, it means that our equations must bend around the behavior of light to stay consistent with what nature is telling us.

One might ask: If spacetime is mathematically deformed, doesn't that imply it's physically deformed too? Not quite. In my view, the deformation in our equations arises because light behaves the way it does—it's a mathematical consequence of a physical truth. We're not inventing distortions for the sake of it; we're responding to a fixed reality (light-speed invariance) with a system flexible enough (the language of mathematics) to describe it.

So, while space and time stretch and shrink in our models, these are structured adjustments—guided by reality, not imaginative guesswork. To put it simply: "The math has to move because light refuses to."

I know you might be thinking: *"But aren't there experiments that support the literal interpretation of the mathematical spacetime deformation?"* And you're right—that's a valid point. We'll come back to that later. But for now, I want to show you how taking math **too literally** can sometimes[1] lead to **unrealistic conclusions**.

---

[1] Yes, there are times when we shouldn't take math too literally. But in many cases, we do need to use math to understand what's really happening in the world. This raises a tricky question: When should we take the math literally, and when is it just a tool to describe something? That's a deep and interesting discussion—but it's not the focus of this book.

One of the best ways to illustrate this is with a simple example: **the center of mass of a donut.** Physicists often describe the center of mass as the point where an object would balance perfectly if it were spinning or floating in space. For a donut, that point lies in the empty hole at the center. But does that mean there's actual mass inside the hole? Of course not. The math tells us the center of mass is located there—but that point isn't a physical thing. It's just a mathematical construct, a convenient way to describe how the mass is distributed around the donut. The hole contains no mass at all. This example reminds us that math is a tool for describing reality—not reality itself.

Here's another example. Say your bank account shows "–100" dollars. Does that mean you physically have **negative coins** in your wallet? No—it just means you owe money. The negative number helps describe the situation, but it doesn't represent something you can see or hold.

Now let's return to our earlier topic—**light**.

To explain why all observers measure the same speed of light, physicists had to adjust their equations. The math showed that time **slows down** and distances **shrink** apparently for fast-moving objects. But that doesn't mean clocks are stretching like rubber bands or that rulers are actually squishing. Instead, it means that mathematics, as our tool for describing reality, adjusts space and time variables to fit what light is doing. The math captures this beautifully. But if we take those equations too literally, it can sound like **space and time are physically bending** like cartoon objects. Think of mathematics like a

map. It helps us navigate the landscape of reality, but it's **not the landscape itself**. If we mistake the map for the territory—if we treat every mathematical symbol as a physical object—we risk drawing conclusions that sound bizarre, or even impossible.

That's why we have to be careful. The math might be perfect, but **how we interpret it** still matters.

3.4 Beyond Light: Reinterpreting Motion for Massive Objects

Now let's shift gears and talk about something different—something heavier.

Up to this point, we've been focusing on **light**, which is massless. But relativity doesn't just claim that spacetime bends for light—it applies the same rules to anything moving fast enough. And by "fast," we don't mean highway speeds—we're talking about **velocities approaching the speed of light**. According to the theory, even massive objects—like particles, atoms, or spacecraft—experience distortions in time and space when they reach these extreme speeds. This is where time slows down, lengths shrink, and spacetime itself is said to deform.

But here's the question I want to explore: **Can we explain these effects without assuming that spacetime is actually warping?** I believe the answer is yes.

Let's return to a key point we discussed earlier. One of light's strangest features is that its speed is **completely independent of the speed its source**. Meaning, no matter how fast the flashlight is moving when it emits a beam, the light

always travels at the same speed to any observer. That's not how most things work in the everyday world. For example, if you throw a ball while standing still, it moves at one speed. However, if you are throwing it while running, it moves faster, because it's getting a boost from your motion. That's how objects with mass normally behave. Their speed is *tied* to the speed of whatever launched them.

Now let's take that idea and apply it to real, massive particles (meaning particles with mass)—like protons, ions, or muons. In today's particle physics labs, these objects are accelerated to mind-bending speeds—sometimes 99.9% the speed of light. And strikingly, their speed seems to have nothing to do with the motion of the device that launched them. This setup turns out to be remarkably similar to the behavior of light. In both cases, the speed of the moving object—whether it's a photon or a high-speed particle—doesn't depend on the speed of its source. This kind of speed independence is a curious feature in nature when things travel at high speed—and it's exactly what makes light so strange.

So, how could we interpret such strange behavior for massive objects? Well, things start to make even more sense when we consider one more detail: the speed of the accelerator itself. If the accelerator is stationary and the particle shoots off at tremendous speed, the difference between their speeds is so extreme that they are **mathematically nearly incomparable** due to the huge difference between them. This **mirrors what we see with light**: no matter how fast its source is moving, light always travels at the same speed. Likewise, when an ordinary object is moving fast enough compared to its source,

the source's speed becomes negligible—so much so that the object's velocity is independent from the speed of its emitter.

This unusual kind of motion—where an object's speed no longer depends on the speed of its source—is what originally led scientists to rethink how they describe time and space. With light, they saw that its speed stays constant no matter how fast the source is moving. To make sense of that, they adjusted the way time and distance are represented in the math. Now, in modern experiments, we see that fast-moving particles (massive particles) can show a similar kind of independence. When a particle shoots out at an extremely high speed—and the device that launched it is barely moving by comparison—it starts to behave a lot like light. In that case, it makes sense to use the same kind of math we use for light.

But here's the key: that doesn't mean the same laws always apply to all fast-moving objects. They apply *in a specific setup*; specifically, when the object's speed is huge compared to its source. If we designed the experiment differently—so that the source was also moving fast, and the difference between the two speeds was smaller—then this light-like behavior might not appear. In other words, the math works here because of how the situation is set up, not because it applies everywhere.

So perhaps what we're seeing, when time appears to slow down for fast-moving particles, isn't a distortion of time itself—but a mathematical adjustment. It's a tool we use to describe motion when an object seems to have broken free from the influence of its source. And maybe, instead of assuming that reality is bending, we're simply bending our formulas to keep

up with how nature behaves in these extreme cases. In the end, it might not be time that's changing—it might just be us, changing how we interpret it.

3.5 Gravity and spacetime

Now, let's bring something new into the discussion: gravity.

Before we talk about gravity itself, let's take a closer look at how **light** behaves—especially when it travels between different heights, like from the ground up to a mountain or from space down to Earth.

Light isn't just something that moves in a straight line—it also **waves** as it travels. You can imagine it like a ripple or a repeating pattern, similar to ocean waves or the flashing of a strobe light. Each wave has two parts:

1. **The distance it travels per wave**—think of this like the space between two peaks of an ocean wave. That's the *spatial* side of light.

2. **The time it takes to complete one wave**—like how often a light blinks, or how fast the waves are hitting. That's the *timing* or *rhythm* side of light.

You can think of light as **pulsing** while it moves—like a runner taking steady steps. The "length" of each step is like the space covered per wave, and the "pace" is how quickly each step lands. These two parts—the size of the step and the speed of the stepping—together describe how light behaves.

Now, here's the important part: When light travels upward—away from Earth and into weaker gravity, like heading up a mountain or into space—its rhythm slows down. Imagine a runner whose footsteps become a little more spaced out in time, even though they're still moving forward. The steps take longer to land.

But when light travels downward, into stronger gravity—closer to Earth's center—its rhythm speeds up. The runner begins stepping more quickly, as if gravity is pushing the beat faster. The pattern tightens—not in size, but in pacing. In this way, gravity seems to affect the timing between each wave, making the flashes of light come sooner or later depending on where they are.

Physicists often describe this as a shift in the wave's timing, but they don't usually talk about how far each wave travels – *the spatial side*. The focus is mostly on how fast or slow the steps are landing, not how far apart they are.

Before we go further, let's take a look at what physicists actually say about this. Specifically, how do they describe what happens to light's **spatial** pattern and **rhythmic** pacing when it moves between two different levels of gravity—like from the surface of the Earth to a higher altitude, or vice versa?

Physicists make one thing very clear: **the speed of light must always stay the same**, even when gravity changes. That's a cornerstone of modern physics. So if the *rhythm*—the timing between pulses—changes due to gravity, then something else has to adjust to keep the speed constant. And that "something" is the *spatial* pattern. In other words, if gravity makes the *rhythm*

faster, the distance light travels with each wave must shrink to keep the overall speed unchanged. For example, light near sea level—where gravity is stronger—ticks faster than light up in the mountains. But since the speed of light can't increase, the only way to account for that faster *rhythm* is for each wave to take a shorter *spatial* step. So down near Earth's surface, light's *rhythm* tightens, and its wave pattern becomes slightly more compressed than it is higher up.

Let's break it down with a simple example.

Suppose light is moving at **10 meters per second (the speed)**, and each pulse happens every **1 second (the *rhythm*)**. That means each wave travels **10 meters** per pulse (the *spatial* step). So far, everything matches: **10 meters ÷ 1 second = 10 meters per second.**

Now imagine the timing changes—perhaps gravity causes the pulses to slow down to **1.25 seconds** apart. But the speed of light must still be **10 meters per second**. The only way this works is if each wave now covers **12.5 meters** instead of 10: **12.5 meters ÷ 1.25 seconds = 10 meters per second.**

The opposite is true as well: if the pulses come faster—say, every **0.5 seconds**—then each wave would only need to cover **5 meters** to keep the speed the same: **5 meters ÷ 0.5 seconds = 10 meters per second.**

So, if the rhythm (the pulse timing) changes, and the speed stays fixed, then the **distance covered by each pulse must change too.** That's the only way the numbers add up.

So, how physicists describe it ? they say that gravity bends space and time—that it distorts the very fabric of reality. That's the standard explanation. And do they have evidence to support this idea? Yes, they do. For example, they've measured how long it takes light to travel from outer-space to Earth and found unexpected discrepancies in the timing. To explain this, they proposed that space and time themselves must be curved—stretched or compressed by the gravity of massive objects like stars. And remarkably, the math lined up. The numbers fit beautifully. These findings convinced many physicists that gravity really does warp spacetime. *But is that the only possible interpretation?* **Could there be a more grounded or intuitive way to understand what's happening—one that doesn't require imagining space and time themselves bending? I believe there is. And that's what we'll explore next.**

The alternative view I'm proposing isn't something that can be explained in a quick sentence. It needs a bit of unpacking—because the explanation we're challenging is rooted in one of the most well-established theories in physics. That theory is called general relativity. To understand the alternative interpretation, we'll first need to explore how this theory explains gravity and how it uses math to describe the world. Then, we'll take a fresh look at it—not to reject its equations, but to rethink what those equations might really mean.

"Curvature of spacetime in General Relativity".

In general relativity, physicists created a mathematical model that connects space, time, gravity, mass, and energy. But how did they do that? They used geometry.

To make the model more visual and intuitive, they imagined space and time as a kind of sheet—like a stretched towel or rubber surface. When a heavy object (representing mass and energy) is placed on this sheet, it creates a dent or a curve. That dent represents the effect we call gravity. Based on this model, physicists looked at their equations and concluded: "Mass and energy bend space and time, and that bending is what we experience as gravity."

But I see it differently.

To explain why, let's go back to where it all started—with Einstein. He noticed something interesting: when you're in an accelerating vehicle, like a plane during takeoff, you feel a pulling force pushing you into your seat. That sensation, he realized, feels very much like gravity. This insight became the seed of general relativity.

Einstein wanted to describe the connection between acceleration and gravity using mathematics. But acceleration isn't just a single variable—it involves both space and time. Acceleration is more than just speeding up or slowing down. It describes how motion changes—and motion always happens across space and through time. For example, when a car accelerates, it's not just gaining speed—it's gaining speed in a direction, and doing so over time. So, to describe acceleration fully, *you need both space and time together*. That meant Einstein needed a mathematical tool that could represent both of these—space and time—at once.

Geometry seemed like the perfect choice to represent acceleration. Geometry might sound like something reserved

for high school math class, but in physics, it has proven to be an incredibly powerful tool—especially for describing relationships like distance, direction, and change. That's why Einstein turned to geometry when trying to understand motion under acceleration. He saw that geometric shapes—like curves and surfaces—could be used to represent how things move and interact in both space and time.

The key idea was this: if you wanted to describe how acceleration affects motion, you could represent it as a kind of curvature on a geometrical sheet. This sheet, made from space and time coordinates, wasn't meant to be a literal thing—it was a mathematical map, a model to help visualize how acceleration behaves. The bends and curves in that sheet weren't distortions of reality itself, but a clever way to encode the effects of forces, motion, and gravity using geometry.

But over time, something interesting happened. Physicists began to look at that geometrical sheet—not just as a representation of acceleration—but as space and time themselves. The model was so effective, so mathematically accurate, that many took it a step further and interpreted the curvature not just as a symbolic tool, but as a physical truth: that space and time were literally bending.

This shift in thinking led to the widely accepted idea that spacetime itself is a real physical entity that stretches and shrinks and deforms—as if the universe were built from a stretchy fabric that deforms under the influence of mass and energy. The famous image of a rubber sheet dipping under a heavy ball

became more than a metaphor; it became the dominant way to think about gravity.

But it's worth remembering where this idea started. **The spacetime sheet wasn't originally a picture of physical space or time twisting and turning—it was a way to represent how acceleration behaves**. And if we keep that in mind, we might begin to see room for a different interpretation—one where the math still works, but the meaning behind it changes.

But here's where I disagree—not with the math, but with how the model has come to be understood. *It seems that somewhere along the way, the original purpose of the sheet model was forgotten*. The geometry is mathematically correct, and I fully accept that. But I believe the sheet was meant only as a clever way to represent acceleration. The curvature we see in the model is not proof that space and time themselves are bending. It's a geometric way of encoding variations in acceleration. Those dents in the sheet are not space and time warping—they're simply how gravity, as a form of acceleration, is represented within the geometry.

So, we shouldn't assume that spacetime is actually warping just because the equations involve curvature. Instead, we need to look closely at what each variable represents, and interpret the model in the right context.

So, the alternative interpretation we offer here is this: what appears to be a twisting or warping of spacetime is actually a mathematical map of acceleration in the universe. Wherever the curvature is intense, we're simply seeing a region with stronger

acceleration. And acceleration, by its very nature, is linked to gravity—just as Einstein originally intended. Where gravity is present, so are mass and energy—the physical causes that give rise to it. That is the interpretation I offer.

Before we end, let's briefly return to the behavior of light—how it pulses differently at sea level compared to high up in the sky. Physicists often interpret this change in rhythm and spatial pattern as evidence that gravity is bending spacetime itself—that time slows down and space contracts in stronger gravitational fields. But I see it through a different lens. What we're witnessing, in my view, is simply an interaction between gravity and light. Nothing more. There's no need to invoke time dilation or space contraction. The change we observe is not a sign that time or space is being reshaped—it's a sign of what gravity can do to light as it moves through different regions of the universe. And sometimes, a simpler explanation can bring us closer to the truth.

3.6 Empirical evidence

Now it's time to address the elephant in the room: **experiments**.

- Viking experiment.

In the 1970s, NASA sent Viking spacecraft to Mars. As part of their mission, the Viking landers sent radio signals back and forth between Earth and Mars. These signals had to pass near the Sun, which has a huge gravitational pull.

According to Einstein's theory of general relativity, gravity affects time. Specifically, it predicts that time slows down slightly in stronger gravitational fields. So when the radio signals passed near the Sun, where gravity is strongest, they should have taken a little longer to arrive—not because they traveled farther, but because time itself was flowing more slowly in that region.

Scientists measured how long the signals took to travel between Earth and Mars, and they compared the results with predictions from Einstein's equations. The match was very close: the signals were delayed by exactly the amount general relativity predicted. That delay is known as the Shapiro time delay, and it's often considered strong evidence that gravity stretches time.

But I interpret it differently.

In my view, the delay measured in the Viking experiment doesn't require us to believe that time itself is stretching or that space is bending. The same results can be explained in a different way—one that still uses the same math, but shifts the meaning behind it. As the radio signals passed near the Sun, they were moving through a region where gravity is strong. In that environment, gravity doesn't distort time—it interacts with the signal. It slows its progress ever so slightly, not by warping the fabric of reality, but by influencing the way the signal moves through space. The delay we measure is real—but what it tells us is not that time is bending, but that gravity is exerting its influence on the motion of the signal itself.

So when I apply this alternative interpretation to the Viking experiment, I still get results that closely match what scientists observed. The difference is in what we think is actually happening. Rather than saying space and time themselves are being reshaped, we can say the signal is simply being slowed by gravity's presence—just like a swimmer might move a little slower through thicker water. In this view, the delay doesn't prove that spacetime is deformable. It shows that gravity affects motion. And sometimes, that's all we need to say.

- GPS

Let's talk about GPS—the Global Positioning System. It's one of the most commonly cited examples of Einstein's theories playing out in everyday life. GPS satellites orbit high above Earth and send signals to our phones and navigation systems to help us figure out where we are. But behind the scenes, GPS relies on something deeper than signal strength or satellite coverage—it depends on incredibly precise timing.

Each GPS satellite carries an atomic clock that ticks with extraordinary accuracy. But here's the catch: clocks on satellites don't tick at the same rate as clocks on Earth. If we didn't correct for that, GPS would be off by miles in just a single day. So what causes this mismatch?

According to Einstein's theory of relativity, two key effects are at play: gravity and motion.

Because satellites orbit far above Earth, they experience weaker gravity. General relativity predicts that in weaker gravity,

time ticks faster[2]. So a satellite's clock runs slightly quicker than a clock on the ground.

At the same time, satellites are moving fast—about 14,000 kilometers per hour. Special relativity tells us that moving clocks tick more slowly. So motion pulls the clock rate back a bit.

When scientists add both effects together, they find that satellite clocks tick about 38.5 microseconds faster each day than clocks on Earth. That may sound tiny, but if left uncorrected, it would ruin GPS accuracy. That's why engineers carefully adjust for it.

Now here's where my interpretation comes in.

I agree with the measurements. I agree with the math. The number—38.5 microseconds per day—is right. What I'm reconsidering is the story we tell about *why* it happens.

Physicists often say these timing differences occur because space and time themselves are being stretched, bent, or warped. But I think there's another way to look at it—one that keeps the math, keeps the data, but shifts the meaning behind it.

First, let's focus on what GPS is actually comparing: not light's speed, but the ticking of atomic clocks in different environments.

---

[2] Photons are responding to gravity in a similar manner as atomic clocks but in an opposite way. Basically, the atomic clocks, which are used in GPS, ticks faster in weaker gravity.

Atomic clocks tick based on energy shifts inside atoms. These energy shifts don't need time to be stretching—they respond to gravity directly. In weaker gravity (like where the satellites are), the atoms tick faster. In stronger gravity (like at sea level), they tick more slowly. Not because time is changing, but because the environment affects how the atoms behave.

Now, what about motion? The satellites are moving fast, and that motion affects how their ticking appears to observers on Earth. But again, I don't think this means time is physically slowing down. I believe what we're seeing is a shift in how motion and energy interact. Fast-moving objects become less responsive to small disturbances—they appear to "hold" their speed more firmly (their speed becomes increasingly not dependent on the speed of the observer). In that sense, the satellite's motion creates an observational effect—*how* we perceive the ticking—not a fundamental change in time itself.

So when we put both effects together:

- The satellite's clock ticks about 45.7 microseconds faster per day due to being in weaker gravity.
- It ticks about 7.2 microseconds slower per day due to its motion.
- The net result is the same: 38.5 microseconds faster.

The correction is real. The measurements are precise. But the interpretation can be different.

Instead of saying that time is bending and space is warping, we can say that gravity and motion are influencing how physical

systems—like atoms—behave. GPS still works. The science still stands. But this view keeps us grounded in the physical behavior of clocks and motion, without needing to imagine that reality itself is stretching.

Sometimes, the story we tell about the data is just as important as the data itself.

- Double Pulsar Experiment

Imagine two ultra-dense stars—each the size of a city—locked in a tight, whirling orbit around each other. These are pulsars, spinning neutron stars that send out regular beams of radio waves, like cosmic lighthouses. One extraordinary pair, known as the double pulsar (PSR J0737−3039A/B), has given scientists one of the most precise natural laboratories ever created to test gravity.

What makes this system so special is that *both* stars are visible as pulsars. As they orbit one another about every 2.4 hours, their radio pulses reach Earth in steady, measurable beats. But those beats shift ever so slightly over time, and those shifts tell us something remarkable about how gravity works.

According to Einstein's theory of general relativity, massive objects like these pulsars curve space and stretch time. So, in the traditional view, the pulsars' changing orbits and delayed signals are the result of this invisible warping—space bending, time slowing, and even waves of gravity rippling outward as energy is lost.

The numbers fit beautifully. Every measurement—down to tiny timing changes and orbital shifts—matches what Einstein's equations predict. That's why this system is often hailed as one of the strongest confirmations of general relativity.

But there's another way to read what's happening.

In this book, I've presented a different way to interpret gravity—one that accepts all the data and the math, but offers a new story about *why* these effects occur. I don't believe space is literally bending, or that time itself is stretching. Instead, I see all these effects as reflections of how acceleration behaves in the presence of mass and energy.

Let's break that down.

Take **periastron precession**—the gradual turning of the point where the stars come closest in their orbit. Traditionally, this is explained by curved space. But from my view, it's the result of how acceleration behaves near massive objects. The stars are moving through a region where gravitational pull changes subtly from place to place. These real shifts in acceleration gently twist the orbit over time—no spacetime bending required.

Now consider **timing delays**, like the **Shapiro delay** and **gravitational redshift**. These happen when signals from one pulsar pass near the other before reaching Earth. General relativity says the delay is because time flows more slowly in strong gravity. But there's another way to see it: the delay happens because the signal's path is slightly altered, and the conditions it passes through—regions of varying gravitational

energy—change how the signal behaves. Light doesn't just follow a longer path; its speed and rhythm are influenced by the gravitational environment. No need to stretch time—just observe how light responds to real, physical conditions.

What about **orbital decay**? Scientists say the system is losing energy through gravitational waves—ripples in the fabric of spacetime. Instead, we can describe this decay as energy loss happening *within* the gravitational field itself, caused by how the field dynamically interacts with the stars' motion. The result is the same: the orbit slowly shrinks—but not because space is wobbling.

Even **spin precession**, the slow wobble of each pulsar's rotation, fits into this picture. Rather than being caused by curved space, it's explained as the effect of moving through a complex pattern of acceleration. As the pulsars orbit and interact with each other's gravity, the structure of the gravitational field influences how their spin axes shift over time.

In this reinterpretation, the math stays the same, but the story changes. Instead of thinking of spacetime as a stretchable fabric, we think of it as a map—a coordinate system that helps us track how mass and energy affect motion and timing. What looks like curvature in that map may simply be a way of describing the structure of acceleration in the universe.

So, what does this all mean?

It means we don't have to imagine the universe bending and stretching to explain what we see. The double pulsar still teaches us deep truths about gravity—but maybe those truths

are best understood not as distortions of space and time, but as patterns in how things accelerate and interact in a gravitational field.

In the end, this reinterpretation doesn't reject general relativity—it reframes it. It keeps the predictive power of Einstein's equations but offers a simpler, more grounded explanation of what's really happening behind the math.

- Lithium Ion

Scientists have performed many experiments to test Einstein's theory of relativity, especially the idea that time slows down for objects moving very fast. One of the most striking examples involves lithium ions—tiny, charged particles that scientists can accelerate to high speeds.

In two well-known experiments, researchers sped up lithium ions to a few percent of the speed of light. Then, using precise lasers and atomic clocks, they measured the ions' internal "ticking"—the rate at which they go through energy transitions. What they found was clear: the faster the ions moved, the slower their internal ticking appeared. That's exactly what Einstein's special relativity predicts.

No one disputes the results. The measurements were precise, and the math—based on something called the Lorentz transformation—matched them perfectly. The question is: *what do those results really mean?*

Physicists typically say this proves that time itself slows down for fast-moving objects. But in this book, I offer another

explanation. One that keeps the data and the equations intact, but sees the situation through a different lens.

Here's the key idea: when lithium ions move that fast, they start to behave in a way that feels disconnected from the machine that launched them. Their motion no longer seems like a simple extension of the lab's motion. Instead, they appear to take on their own independent behavior—much like how light travels at the same speed no matter how fast its source is moving.

Why is that important?

Because when an object moves fast enough that its speed no longer depends on the speed of its emitter, we have to adjust the way we relate the two. That's where the Lorentz transformation comes in. It's a mathematical tool that helps us translate between the lab's point of view and the ion's—but it doesn't mean time is actually stretching or that space is physically compressing. It just means that from the lab's perspective, we need to adjust our math to describe how an object behaves when its motion appears to have broken away from its source.

So yes—the ticking slows down when observed from the lab. But that doesn't mean time itself has changed. It means the lithium ion is moving so fast, and so independently, that we need a different mathematical relationship to describe how its behavior compares to the lab's clock.

This is similar to how we treat light. Light always travels at the same speed, no matter who observes it or how fast the

source is moving. And that's why the Lorentz transformations were invented in the first place—to account for that independence. When fast-moving objects start acting similarly—appearing source-independent—we use the same math for the same reason.

So here's the difference:

1. Physicists usually say: "The lithium ions moved fast, so their time slowed down."

2. I say: "The lithium ions moved fast—and in a way that no longer mirrored the motion of their source. That disconnect requires us to adjust our math, not because time is bending, but because we're comparing two very different kinds of motion."

This might sound like a small shift. But it leads to a much simpler picture—one where clocks behave differently not because time is changing, but because motion, energy, and relationships between frames require us to describe them differently. The math still works. The results still match. But what's changed is the story we tell about why.

- Muon Experiment

Back in 1977, scientists at CERN—a major physics lab in Europe—ran an experiment that's often used to "prove" that time slows down when something moves very fast. They studied particles called muons, which are a bit like heavy electrons, and set them racing in a big circular track at speeds close to the speed of light. What they saw was this: the fast-

moving muons lasted longer before decaying than they would if they were standing still. That lined up exactly with Einstein's prediction that time slows down for fast-moving objects.

So—is this proof that time itself actually slows down?

Not necessarily. Let's take a closer look.

To understand this differently, we need to look at how the muons were created. The experiment didn't just shoot muons straight into the loop. Instead, scientists started with protons and smashed them into a stationary wall. That produced other particles called pions. Then those pions decayed—and *that's* when the muons appeared.

Here's why that matters: the entire setup began in a stationary wall—the lab itself. Even though the muons ended up moving incredibly fast, their motion wasn't launched or inherited from something already moving. They weren't "fired" out of a speeding source like a bullet from a moving car. Instead, they emerged from a chain reaction that started at rest. That means the muons' motion appears **detached** from their origin—it's not carried forward from a moving source.

And this gives us a clue.

Light behaves the same way. No matter how fast you move, light always travels at the same speed. It's completely independent of its source's motion. That's what makes light so special. And in this experiment, the muon—though it's not light—starts to behave similarly. Its speed seems to exist on its own, not anchored to the thing that created it.

This is where my interpretation comes in.

When something moves so fast that it seems detached from its origin, we have to adjust the way we describe it. Physicists do this using the Lorentz transformation—a mathematical tool that relates how time and space look from different points of view. But here's the key: just because we adjust the math doesn't mean time itself is literally slowing down.

In this reinterpretation, the muon's extended lifetime isn't because time is stretching. It's because the lab—our point of view—is so different from the muon's that we need to **rescale our measurements** to make sense of what we see. The transformation we use isn't showing a warped universe—it's helping us compare two vastly different states of motion: one almost still, the other flying at nearly the speed of light.

So yes—the muon really does live longer in our observations. But that doesn't mean time is bending. It means the muon is moving in a way that looks completely disconnected from its source. And when that happens, we need to shift our mathematical tools—just like we do for light—not because reality is changing, but because our way of tracking it must adapt.

Here's a simple way to think about it.

If you're hiking across flat land, a regular map works fine. But if you suddenly reach a steep mountain, that map won't help anymore. You need a topographic map—one that shows elevation. The mountain didn't change because you picked a

new map—you just needed a better tool to describe where you are.

That's how I see the muon experiment. The muon didn't experience slower time. We just had to change how we describe its motion. And once again, the effect is real, the math works—but the story we tell about it might need to change.

- Atomic Clocks in Flight

In 1971, a group of scientists flew atomic clocks around the world on commercial airplanes. Their goal was to test Einstein's prediction that time moves differently depending on how fast you're going and how close you are to gravity. This was a big deal—because if they were right, it meant that time could actually *slow down* or *speed up* depending on your motion. The experiment was seen as direct proof of Einstein's theory of relativity.

So, what did they do?

They put extremely accurate atomic clocks—special devices that keep time by tracking tiny changes in atoms—on planes. One plane flew eastward, the other westward. When the flights were over, they compared the clocks from the planes to clocks that stayed on the ground. They found small differences in the time shown by the clocks. And those differences matched what Einstein's theory predicted.

At first, the experiment seems like clear-cut evidence for Einstein's predictions. But here's where I raise a caution flag.

Atomic clocks in the early 1970s weren't nearly as precise as today's. Even when two clocks sat side by side in the same lab, they could drift apart by as much as a millionth of a second per day. That doesn't sound like much—but when you're trying to measure a few billionths of a second during a flight, that margin of error is huge.

The scientists who ran the experiment knew about this problem. They tried to solve it by averaging the results from four clocks. But that's a very small sample size—not enough to rule out random errors. Even the researchers admitted that they didn't collect enough data to do a solid statistical analysis. And they also estimated their margin of error at around 30 nanoseconds—which, again, is close to the time differences they were trying to measure.

There were other issues, too. The clocks may have been affected by changes in temperature or air pressure during the flights. The planes didn't move at a constant speed or altitude. And the clocks spent a lot of time sitting still on the ground in different airports, which adds even more complexity.

Some experts, including the scientist who built the atomic clocks used in the experiment, later said that the results weren't reliable enough to test Einstein's theory. Others pointed out that the experiment didn't properly account for all the different forces and motions acting on the planes.

So what's the takeaway?

It's not that the experiment was a failure—it was a bold and innovative effort at the time. But its limitations mean that we

should be careful about treating it as airtight proof that time itself physically stretches or slows down.

My suggestion is simple: Before we accept the idea that time bends or stretches based on a small, imprecise experiment from more than 50 years ago, we should take a closer look. Better technology and better methods are available today. If the experiment were redone now—with more accurate clocks, better environmental controls, and more data—it could offer stronger evidence.

Until then, we should keep an open mind about what the original experiment really proved—and what it didn't.

- Gravity Probe A Experiment

Let's take a journey back to the 1970s. A group of scientists launched a small spacecraft carrying one of the most accurate clocks ever built—a hydrogen maser—into space. The mission was called Gravity Probe A (GP-A), and its goal was to test a strange prediction of Einstein's general relativity: that gravity changes the way time flows.

Here's how the experiment worked. According to the standard view of relativity, time ticks more slowly in stronger gravity and more quickly in weaker gravity. So the scientists sent the clock to an altitude about 10,000 kilometers above Earth, where gravity is weaker, and compared it to a matching clock on the ground. Signals were sent between the two using radio waves, and the clocks were carefully monitored.

What they found matched Einstein's predictions perfectly. The clock in space ticked slightly faster than the one on the ground.

Physicists typically explain this by saying that time itself flows differently depending on your location in a gravitational field. That's why the higher-up clock "ticks faster." It's not broken—it's just experiencing a different rate of time, as if time itself speeds up with altitude.

But there's another way to interpret what happened—one that keeps all the math and measurements exactly the same, but tells a different story about *why* the clock ticks faster.

Let's step back for a moment and think about what a clock actually does.

An atomic clock, like the hydrogen maser used in Gravity Probe A, keeps time by measuring energy changes inside atoms. These changes—tiny, repeated transitions—act like a rhythmic beat, counting off time one "tick" at a time. The rate at which these ticks happen depends on the environment the clock is in.

Now here's the key idea: instead of saying that time itself flows faster or slower, we can say that **the environment—specifically, the gravitational potential—affects how the atoms behave**. In weaker gravity (like higher up in space), the internal behavior of the clock changes in a subtle but measurable way. It ticks faster not because time is speeding up, but because the clock is physically responding to its surroundings.

So in this interpretation, there's no need to imagine time bending or stretching. Time is still the same abstract parameter we use to measure relationships between events. What changes is the behavior of the matter inside the clock, because it's sitting in a different gravitational landscape.

Both interpretations agree on what we observe: the clock in space ticks faster than the one on the ground. But while the traditional view says, "Time itself is flowing differently," I suggest a simpler view: **"The clock is behaving differently because gravity is affecting how it ticks."**

In this picture, the gravitational redshift—the difference in ticking between the two clocks—is still real. It's still governed by the same equations. But instead of saying that gravity stretches time, we say that gravity influences energy—and energy shapes how clocks operate.

The result is the same. But the story we tell about it changes.

And that's the heart of this reinterpretation: not changing the facts, just changing the way we understand what those facts are telling us.

- Pound and Rebka Experiment

In the 1960s, two scientists—Robert Pound and Glen Rebka—set out to test a strange idea from Einstein's theory of gravity. They wanted to see if gravity could slightly change how light behaves as it moves upward or downward through a gravitational field.

They did this by sending a special kind of light, called gamma rays, from the bottom of a tall tower to the top. If Einstein was right, the light should lose a small amount of energy as it climbed upward against gravity. But how do you detect such a tiny change?

They used a very precise technique based on something called the Mössbauer effect, which allowed them to detect tiny shifts in how the light was absorbed. You can think of this like trying to match musical notes. If one note is even slightly off in pitch, a trained ear—or a precise instrument—can tell. The same idea applies here: they compared the "note" of the light emitted at the bottom with what was absorbed at the top. If the pitch was even a little off, they would know the light had changed.

To make that more relatable: imagine a tuning fork—a small metal tool that vibrates and makes a very pure tone when struck. Musicians use it to check if their instrument is in tune. If another instrument plays a note that doesn't match the tuning fork, you'll hear it as being too sharp or too flat. In the same way, the detector in this experiment was like a tuning fork for light—it could tell if the light that arrived was slightly off from what it was expecting. If gravity changed the light's energy even a little, that "pitch" would shift—and that's exactly what they found.

Physicists interpret this result by saying that time runs more slowly in stronger gravity. So, at the bottom of the tower—where Earth's gravity is stronger—they say time ticks more slowly than it does at the top.

Here's why that matters: light, just like a clock, repeats something over and over—like a cycle or a pulse. So when light is emitted from lower down, where time is supposedly running slower, its pulses are "slower" too. When those pulses are measured higher up—where time runs "faster"—they seem stretched out, as if the light has lost energy. This is what physicists call gravitational time dilation—a fancy way of saying "time flows at different speeds depending on how strong gravity is."

I agree completely with the observations from this experiment. What I disagree with is the story physicists tell about what's causing them.

Instead of saying that time itself is changing, I say that light's behavior changes directly because of gravity. More specifically, when light travels through regions with different levels of gravity, its energy changes—and that's what we're really observing.

You don't need to imagine time stretching or space bending. Instead, just consider this:

In simple terms, the energy of light is tied to how fast it pulses—like a blinking light. The more energy it has, the faster it blinks. So, if gravity changes the light's energy, it also changes how quickly that blinking happens. But there's another part of the story: each blink also travels a certain distance, like the length of a single stride in a walk. So we can think of light as moving in a series of steps—blinking forward, step by step. The "blinking speed" tells us how fast it repeats in time, while the "step size" tells us how far it moves with each repeat.

Now here's the key idea: in my interpretation, the size of each step stays the same, because I don't believe gravity stretches or shrinks space itself. So if every step still covers the same distance, but the blinks happen more quickly or more slowly, then the only thing that could have changed is how fast the light is moving overall. Just like a person taking the same-sized steps but walking faster or slower depending on how quickly they step.

But Doesn't Light Always Move at the Same Speed? Yes—and I fully accept that. I believe that in any one place, no matter who's watching, light moves at the same speed. Everyone in the same location, no matter how they're moving, will agree on the speed of light there. That's a key principle I stand by.

Here's the important idea: I believe that light always moves at the same speed for everyone, as long as the surrounding gravitational field stays the same. Whether someone is standing still or moving, if they're in the same gravitational conditions, they'll all measure the same speed for light. But when light travels through areas where gravity changes—like moving upward or downward in a gravitational field—its speed can also change. And when that happens, everyone observing it will see the same change. The light doesn't behave differently for different people—it simply responds to gravity in a way that's consistent for all.

So what's the real difference? Physicists say:

"Light changes because time itself slows down when gravity is stronger."

I say:

"Light changes because gravity affects how quickly it pulses and how fast it moves—without needing time itself to stretch or slow down."

Both explanations match what we see in the experiment. But mine doesn't require us to believe that time or space is literally deforming. It just says that gravity changes how light behaves, and that's enough to explain the result.

4 PART B: SPECIAL RELATIVITY.

The theory of special relativity, established by Albert Einstein in 1905, rests on two foundational postulates: the constancy of the speed of light in a vacuum for all inertial observers, and the equivalence of the laws of physics in all inertial frames. These postulates lead to profound consequences, including the relativity of simultaneity, time dilation, and length contraction—phenomena that have been both mathematically formalized and experimentally corroborated. Among these, the notion that time itself is malleable—dilated by relative motion—stands as one of the most philosophically unsettling implications of the theory.

This chapter revisits special relativity not to challenge its mathematical framework, but to explore whether its observed effects—like time dilation and length contraction—can be explained in a way that doesn't require space and time to physically stretch or compress. Specifically, I aim to examine whether the observed phenomena commonly ascribed to a "malleability of time" can be understood using a different explanation—one that keeps the same equations and predictions, but views time dilation not as a real slowing of time, but as a mathematical adjustment made to keep observations consistent.

We begin by reexamining Einstein's original flashlight thought experiment, section 4.1, which serves as a simple and memorable example to explain why the speed of light always appears the same to all observers, no matter how they are moving. Through a careful analysis of this example, I propose

an alternative interpretation of why the speed of light remains invariant to all observers, preparing the reader to rethink how motion, speed, and time are related when objects move near the speed of light..

Building on the discussion of the flashlight thought experiment, the next section (section 4.2) extends the analysis to the Lorentz transformation. In this context, the transformation is reinterpreted in a manner that does not require any deformation of time or space. The implications of this perspective will be developed and clarified within the section itself.

Finally, the discussion is extended to include massive objects—that is, objects with non-zero mass. This section (section 4.3) uses the same approach to examine whether time dilation and length contraction for fast-moving objects with mass can also be explained without assuming time and space are physically altered.

As before, the treatment is framed without invoking any deformation of time or space. The details and implications of this reinterpretation are developed within the section itself.

In short, this chapter offers a clear and scientifically supported reinterpretation of special relativity, preserving its formal structure and empirical power, while challenging the notion that time is malleable.

4.1 Preliminary distinction

Let us revisit the thought experiment given by Einstein in his seminal work published in 1905 [2]. Suppose a flashlight emits light from location A at time t_A toward location B. Then, at the time t_B, the light reflects back from location B towards location A. The light arrives at the location A at time t'_A. In such a scenario, the formula below will clearly be satisfied.

$$t_B - t_A = t'_A - t_B \tag{1}$$

The experiment mentioned above involves light, whose approximate speed we know is about $300 \times 10^6 \ {}^{m}/_{S}$. For brevity, we will denote the light's speed as c. Therefore, the following speed equation holds true for the above experiment, as speed is merely distance traveled per time unit.

$$t'_A - t_B = t_B - t_A = \frac{d_{BA}}{c} = \frac{d_{AB}}{c} \tag{2}$$

In the above equation, d_{BA} represents the distance from location B to location A, and vice versa for d_{AB}. Notice that in the above thought experiment, the flashlight (or the emitting source) is stationary.

A key property of light is that it always travels at the same speed, no matter how fast its source is moving – suppose the source's speed is v. Therefore, we need to modify the thought experiment by using a moving flashlight with speed Q. The modified thought experiment is as follows:

- There are two observers, and both are located at location A. One of the observers is holding a flashlight.
- Then, two events happened at time t_A simultaneously.
    - First event: The person holding the flashlight, location A, and location B all start to move away from the other observer in one direction and at a constant speed v in a straight line. So, we have now two observers; one is stationary, and the other is moving with speed v. Let's assume their speed jumped from zero to v instantly. The flashlight is always located at Location A, as they are both traveling at the same speed.
    - The second event was that the moving observer turned on the flashlight, and a light was emitted from location A toward location B.
- The light arrived at location B at time t_B. This step completes the light's outbound trip.
- Then, at time t_B, the light was reflected immediately back from location B towards location A. The light arrived at location A, at time t'_A. This step completed the light's return trip.

Given that light travels at a constant speed, irrespective of the flashlight's speed, the stationary observer would perceive the light speed as equal to c during both the outbound and return trips. Thus, from the perspective of the stationary observer, (1) and (2) are valid.

For the observer moving with the flashlight, the situation looks different. During the outbound trip, the moving observer

will see the light speed as $c - v$, because he is moving in the same direction as the light. Conversely, he will set the light speed to be $c + v$ during the return trip. From the moving observer's perspective, (2) will appear as shown in (3) and (4).

$$time\ of\ outbound\ trip = t_B - t_A = \frac{d_{AB}}{c - v} \tag{3}$$

$$time\ of\ return\ trip = t'_A - t_B = \frac{d_{BA}}{c + v} \tag{4}$$

If rearrange (3) and (4), we will obtain the following:

$$distance\ of\ outbound\ trip = d_{AB} = (t_B - t_A)(c - v) \tag{5}$$

$$distance\ of\ return\ trip = d_{BA} = (t'_A - t_B)(c + v) \tag{6}$$

Above four equations show that, from the moving observer's point of view, the light takes different amounts of time to travel out and back and covers different distances too. In other words, for the moving observer, both time and space dilate and contract, but not for the stationary observer. How is the physicist nowadays interpreting the above phenomena? They have this interpretation:

Adopted interpretations by physicist nowadays:

The moving observer is experiencing time and space dilation. If he moves faster, he will experience more severe dilation.

In this book, I argue that the conventional interpretation of the flashlight thought experiment overlooks a more

straightforward explanation rooted in the physical nature of light itself. The speed of light remains constant regardless of the motion of its source—a remarkable but plainly observable phenomenon in nature. This invariance is not an abstract postulate but a direct consequence of the fact that light is massless and does not inherit the momentum of the source that emits it. Given this, I find no compelling reason—either conceptually or physically—to invoke time dilation as a necessary explanation. The idea that time has to slow down just to explain light's behavior adds an extra layer of complexity that may not be needed.

What we observe as differences in space and time between the outbound and return trips are, in fact, mathematical consequences of preserving light-speed invariance across reference frames. These adjustments are not fictional or detached from reality—they faithfully describe what we measure. However, their meaning depends entirely on how we interpret the variables involved. The structure remains consistent with empirical observation, but the conceptual framing need not rely on the notion that space and time themselves are being physically altered. To make this distinction clearer, consider replacing the flashlight with a gun that fires a bullet. Because the bullet's speed depends on the speed of the gun, the asymmetry between outbound and return legs disappears. This contrast reinforces the idea that the peculiarities observed in the light-based case arise from the unique, source-independent behavior of light—not from any fundamental change in the fabric of time or space. The sections that follow build on this insight to offer a coherent alternative interpretation.

Alternative interpretation:

The invariance of light's speed is a natural physical phenomenon—not a theoretical abstraction—arising from the fact that light is massless and does not inherit the momentum of its source. The resulting differences in space and time across frames are real but purely mathematical—used to preserve consistency with this behavior—not evidence that time or space physically deform. Time dilation, in this context, is conceptually unnecessary and adds complexity where a simpler explanation suffices.

4.2 Lorentz Transformation

In this section, I show how light's constant speed in three-dimensional space seems to require time dilation—at least under the conventional interpretation. Then, I will offer a reinterpretation that explains the same effect without needing to assume that time physically slows down.

4.2.1 Lorentz Transformation

The previous section provided an example of light moving in one spatial dimension relative to a stationary frame of reference. However, we need to generalize it to mathematically map all three spatial dimensions between a moving and stationary frame of reference. Einstein did it in his 1905 seminal work [2] by using rays, and he arrived at the Lorentz transformation as known in contemporary textbooks of physics. The Lorentz (LR) transformation is a set of equations in physics that relate the spatial and temporal coordinates of two frames of reference moving at a constant velocity relative to each other; it was discovered originally by Lorentz [3]. However, it forms the foundation of Einstein's theory of special relativity.

It is important to mention the basis or assumptions that led Einstein and Lorentz to discover the LR transformation, and they are summarized in the two bullets underneath.

- Einstein derived the LR transformation by analyzing how a spherical light wavefront appears in both stationary and moving frames of reference. Then, he analyzed thoughtfully how it can be perceived in a

stationary and moving frame of references with an intention to find a generalized mapping between them.

- Originally, the Michelson-Morley experiment was about luminiferous ether by measuring differences in the speed of light in different directions. Light was the tool used to probe the properties of the ether in this experiment. Lorentz's work was focused on electromagnetic theory and the behavior of charged particles. He directly tried to solve the problems caused by the Michelson-Morley experiment while keeping the idea of ether alive with his length contraction hypothesis and later the Lorentz transformation [3].

Since LR transformation is a well-known mathematical formula, it is reasonable to omit its explicit presentation here. However, it suffices to say that LR transformation adjusts the coordinates of space and time using factors involving the relative velocity between two frames of reference and the speed of light, ensuring that the laws of physics remain consistent across all frames. The physicists interpreted LR transformation as follow:

Physicist's Interpretation:

According to Lorentz transformation, time dilates and length contracts with respect to two different frames of references moving at a constant relative velocity v *with respect to each other. The time dilates and length contracts in the moving frame* $(\Delta t, L)$ *with respect to the stationary frame* $(\Delta t_0, L_0)$ *with a factor of* γ *according to the following relations:*

$$\Delta t = \gamma \Delta t_0$$

$$L = (1/\gamma)L_0$$

Such that

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

The Lorentz transformation, as presented above, has been rigorously confirmed through experimental observation—a point that will be explored in detail later in this book. While I fully accept the mathematical correctness of these transformations, I challenge the conventional interpretation that they indicate a physical dilation of time or contraction of space.

As discussed in the flashlight thought experiment, the defining feature that necessitates such transformations is the invariant speed of light—a phenomenon rooted in the physical fact that light, being massless, does not carry the momentum of its source. This behavior is not theoretical speculation but a direct consequence of nature. The Lorentz transformation, originally formulated to describe this precise behavior, mathematically adjusts time and space coordinates to ensure consistency with this observed invariance. These changes reflect how we adjust our measurements between frames—they are real but mathematical, not signs that time or space itself is physically changing.

This connection is essential because the Lorentz transformation was historically formulated to describe the propagation of light, or more generally, massless entities. Einstein's use of a spherical light wavefront in his postulates, and Lorentz's original work on electromagnetic waves, both

reflect this origin. The flashlight thought experiment illustrates the exact scenario the Lorentz transformation was built to model—how light behaves when emitted from a moving source. Recognizing this link helps clarify that the transformation factor γ accounts specifically for light's distinctive source-independent speed.

Later in this book, I will address the broader claim that the Lorentz transformation applies to all objects moving at high velocities, not just light. For now, it is important to recognize that its foundation (Lorentz Transformation) lies in modeling the behavior of light, and that the mathematical form need not be interpreted as proof that time and space themselves undergo physical alteration.

Therefore, we offer an alternative interpretation to LR transformation without invoking physical distortion of space or time as follows:

Alternative Interpretation:

The Lorentz transformation was originally developed to model the behavior of light—specifically, its invariant speed regardless of the source's motion. This invariance is a physical consequence of light's masslessness and lack of inherited momentum and requires mathematical adjustments to time and space across frames. These adjustments reflect how we adjust measurements between observers to keep them consistent, without needing to believe that time slows down or space contracts in any physical way.

In the perspective of the moving frame $(\Delta t, L)$ *with respect to the stationary frame* $(\Delta t_0, L_0)$*, the time must be amplified mathematically*

and length must be attenuated mathematically with a factor of γ *according to the following relations:*

$$\Delta t = \gamma \Delta t_0$$
$$L = (1/\gamma) L_0$$

Such that

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

4.2.2 Proper Time Invariance

Some readers might assume that the Proper Time Invariance (PTI) principle conflicts with the alternative reinterpretation proposed in this work but, as we'll explain, it actually fits within the new framework. To address this potential misunderstanding, we have dedicated a separate section specifically to clarify the relationship between PTI and our interpretation.

Let us begin by presenting the PTI principle in its mathematical form:

$$(\Delta\tau)^2 = (\Delta t)^2 - \frac{1}{c^2}[(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2]$$

Where

- $\Delta\tau$ is the differential of proper time measured by a moving observer,
- Δt is the differential of coordinate time measured by a stationary observer,
- c is the speed of light, and

- Δx, Δy, and Δz represent the spatial displacements of the moving object.

By inspecting the mathematical structure of PTI, we observe that the spatial displacement term makes $\Delta t \neq \Delta \tau$. As a result, the time measured by the moving observer ($\Delta \tau$) is less than the time measured by the stationary observer (Δt).

Does PTI conflict with the alternative interpretation offered in this book? The answer is no. The PTI expression above is derived directly from the Lorentz factor γ, which is a central part of the Lorentz transformation. Since PTI is a derived result rather than a fundamental postulate, the reinterpretation of time dilation still holds.

4.3 objects with mass at High speed

The previous section was about light. This section extends the discussions to nonlight objects, or objects with mass. Physicists assert that objects with mass moving at relativistic speeds experience time dilation and space contraction, and they found an empirical basis to think that LR transformation applies not only to light and photons but to everything that travels at high speed. As physicists have interpreted a wealth of empirical evidence to support this conclusion, in this section, we are going to offer different interpretations.

Before examining the empirical evidence, we must first establish a theoretical framework that will serve as a basis for evaluation. According to the relativistic velocity addition (RVA), if an object is moving at speed u_0 with respect to its

emitting source and the emitting source is traveling at speed v with respect to a stationary observer, then the speed of the moving object u from the perspective of the stationary observer is calculated as shown in (6).

$$u = \frac{u_0 + v}{1 + \frac{u_0 v}{c^2}} \tag{6}$$

By inspecting the formula in (6), amazingly, when the object's speed approaches the speed of light (meaning $u_0 \approx c$) and the speed of its emitting source approaches the speed of light (meaning $v \approx c$), the speed of the object with respect to a stationary observer will be equal to the speed of light (meaning $u \approx c$). Thus, the physicists concluded from (6) that no observer measures a speed exceeding the speed of light. Thus, the contemporary interpretation of RVA as follow:

Interpretations of RVA by physicist:

The relativistic velocity addition (RVA) formula, as shown in (6), ensures that no observer can observe a speed of anything exceeding the speed of light. This applies to objects with masses, like protons.

Aside from RVA, wouldn't it be reasonable to assume that the speed of an object with mass, traveling much faster than its source, is independent of the source's speed? Yes, it is justifiable! In this case, when an experiment is set up to accelerate an object with mass to high speed while its emitting source is almost stationary, this object would apparently behave as light does; its speed is independent of the emitting source speed. Even though this conclusion is intuitive, we'll represent it again using the RVA to gain scientific acceptance. Thus, let

us investigate the RVA formula in the case of an object traveling at high speed whereas its emitting source is traveling at low speed; so, let us say $u_0 = 0.85c$ and $v \approx 0$ and substitute them in (6), as shown in (7). The stationary observer will notice from Equation (7) that the object is traveling at nearly 85% of the speed of light.

$$u = \frac{0.85c + 0}{1 + \frac{0}{c^2}} = 0.85c \qquad (7)$$

We can draw numerous conclusions from the scenario above. However, the conclusion that is concerning us here is the following. For objects with mass, like protons, the speed of the emitting source is irrelevant if it is very low with respect to the speed of the traveling object. Does this behavior look familiar? Yes, it looks like light, as its speed is independent of the speed of its emitting source. Therefore, let us draft this conclusion in Note 1 for future reference.

Note.1:

When objects with mass—such as protons—are accelerated to speeds approaching that of light, their final speed becomes increasingly insensitive to the motion of their emitting source. In this high-energy regime, their behavior begins to resemble that of light in the sense that their velocity becomes less dependent on the source's velocity.

If an object behaves approximately similar to the light, then time dilation and space contraction will be observed in the moving reference frame. However, from the discussion we had about light, we know that time dilation and space contraction are not an actual twist in reality; they are mathematical

adjustments, not physical distortions, to account for the constancy of the speed of light regardless of the motion of its source. Thus, we are going to edit the physicists' interpretations of RVA by including a special case that does not require deforming space or wrapping time.

Alternative Interpretation:

When an object with mass—such as a proton—moves at relativistic speeds far exceeding that of its emitting source, its velocity appears increasingly independent of the source's motion, resembling the behavior of light. According to the principles of special relativity, Lorentz transformations are then used to mathematically adjust time and space across frames— so that even though observers measure different values for time and space, those differences can be reconciled through mathematical adjustments—without needing to believe that time or space are actually changing.

The offered alternative interpretation can account for many empirical tests on objects with mass traveling at high speed, visit section 6.

5 PART C: GENERAL RELATIVITY

This chapter explores a foundational reconsideration of general relativity. While the mathematical formalism of Einstein's theory is left intact, its physical interpretation—particularly concerning spacetime curvature, gravity, and the nature of time—is critically reexamined. The chapter is organized to build a clear progression, beginning with the conceptual heart of general relativity and extending outward to its observational consequences and predictive machinery.

The chapter opens with the title **Curvature of Spacetime (section 5.1)**, which presents the core conceptual issue on which the rest of the chapter depends. This section serves as the groundwork for understanding how gravitational phenomena are modeled and what it means, within the standard framework, for spacetime to be curved by mass and energy. All subsequent reinterpretations of time, space, and gravity follow from this foundational reassessment.

To build this reinterpretation systematically, the chapter proceeds by exploring how general relativity deals with time, space, and mass in observational terms—and then offers an alternative interpretation.

The section titled **Time (section 5.2)**, addresses several key phenomena traditionally interpreted as evidence of time behaving differently under gravitational and relativistic conditions. These include **gravitational redshift**, the **Viking signal delay (Shapiro delay)**, **gravitational time dilation**, and **relativistic time dilation**. Each of these plays a critical role in how general relativity links gravity with temporal effects, and

each has been subjected to observational testing through pulsars, radar signals, and clock synchronization experiments.

The next section, titled **Space (section 5.3)**, turns attention to the behavior of light in gravitational fields, focusing on the phenomena of **starlight bending** and **gravitational lensing**. These effects have become iconic visual confirmations of general relativity, illustrating how the paths of photons are altered by the presence of mass and how light from distant sources can be distorted or magnified by intervening gravitational fields.

Under **Mass and Gravity (section 5.4)**, the chapter reviews key orbital phenomena influenced by gravitational fields, including **orbital decay**, **periastron advance**, and **frame dragging and spin precession**. These effects provide crucial insight into how gravity shapes the motion of massive bodies in binary systems and how angular momentum affects the surrounding environment.

In the section **Mass and Energy (section 5.5)**, I examine the process of **mass-energy inference** from observational data and the role of **orbital inclination and geometric effects** in shaping what observers detect. These elements are central to determining the properties of pulsar systems and testing the predictions of general relativity with high-precision timing data.

The chapter concludes with a section titled **Summary: Mass, Energy, Gravity, Acceleration, and Spacetime**, which draws together the major concepts discussed and outlines the implications of viewing gravity, motion, and measurement through a different lens.

In preparing this chapter, it is useful to briefly consider the work of James McKelvie, particularly his article *Revisiting the Matter of Time Dilation in Special Relativity[4]*. McKelvie offers a detailed critique of the prevailing interpretation of time dilation, arguing that clocks in uniform rectilinear motion remain synchronized and that many experiments cited as evidence for time dilation either misapply special relativity or require general relativistic treatment. In this respect, our perspectives overlap: both reject time dilation as a physically real consequence of motion.

However, our approaches (me and McKelvie) also diverge. McKelvie's critique remains focused within the boundaries of special relativity and primarily seeks to discredit misinterpretations of clock behavior. By contrast, this chapter reinterprets the **entire conceptual foundation of general relativity**, including gravitational curvature, light propagation, and field interactions. Where McKelvie challenges specific conclusions, the present chapter proposes a full ontological shift: from a geometric model of spacetime to an acceleration-centered understanding of gravity.

With that foundation, we now begin with the most critical idea of all—**the curvature of spacetime**—and examine how it shapes, and may be rethought within, the framework of general relativity.

5.1 Curvature of spacetime.

The Einstein Field Equations (EFE) are given by:

$$G_{\mu v} = \left(\frac{8\pi G}{c^2}\right) T_{\mu v}$$

Such that

- $G_{\mu v}$: the Einstein tensor, and it represents the curvature of spacetime.
- $T_{\mu v}$: the stress-energy tensor, which represents the density and flux of energy and momentum in spacetime.
- G: it is Newton's gravitational constant.
- c: speed of light in vacuum.

The Einstein tensor $G_{\mu v}$ is encoding the following

$$G_{\mu v} = R_{\mu v} - \frac{1}{2} g_{\mu v} R$$

Such that

- $R_{\mu v}$: The Ricci curvature tensor, describing how volumes in spacetime change.
- $g_{\mu v}$: The metric tensor, which defines the geometry of spacetime—distances, angles, and time intervals.
- R: The Ricci scalar, a scalar quantity representing the average curvature of spacetime

According to the standard interpretation by physicists, the Einstein Field Equations (EFE) express that gravity and spacetime curvature are equivalent. That is, what we perceive as gravitational phenomena are, in fact, manifestations of

spacetime curvature. The left-hand side of the equation $G_{\mu v}$ encodes geometric curvature, while the right-hand side $T_{\mu v}$ encodes the distribution of matter and energy.

The Ricci tensor $R_{\mu v}$ represents the matter-driven part of spacetime curvature that contributes to gravity, but it does not capture all aspects of gravitational phenomena. Thus, we must keep in mind that the Einstein Field Equations (EFE) account only for the portion of gravity sourced by matter and energy — not for free gravitational fields like gravitational waves in vacuum. Therefore, when I mention gravity in the context of the EFE, I am referring exclusively to the gravity sourced by matter and energy.

Let us establish the following observations:

- EFE establish a relationship between spacetime curvature (which represents gravity in this context) and the distribution of matter and energy.
- The left-hand side of the EFE encodes the geometric structure of spacetime, while the right-hand side encodes the matter and energy content that sources gravity.
- The EFE do not describe a causal relationship, and physicists generally agree on this point. They do not state that matter causes curvature or that curvature causes gravity. Instead, the equations express a mutual dependence: where there is curvature, gravitational effects appear—and vice versa. Gravity and curvature are thus interdependent and coexistent within the formalism of general relativity.

- Although the EFE do not mathematically enforce this interpretation, physicists commonly understand matter and energy as the physical source of spacetime curvature and gravitational effects[5]. This is why the stress-energy tensor $T_{\mu\nu}$ is placed on the right-hand side of the equation.

Thus physicists interpret EFE as shown below.

Physicist's Interpretation:

Matter and energy are the physical source of spacetime curvature and gravitational effects, and the Einstein Field Equations (EFE) express their dynamic relationship through a geometric framework. The EFE show that gravitational phenomena are manifestations of spacetime curvature: where one is present, so is the other. Furthermore, changes in gravitational behavior correspond to changes in the curvature of spacetime.

To unpack the complex structure of the Einstein Field Equations (EFE), we can break it down as follows:

- Spacetime is not an absolute entity—it is dynamic—because its structure is determined by the presence and distribution of matter and energy.
- Spacetime exists as a foundational framework, even in the absence of matter and energy; however, without them, its geometry remains flat (i.e., uncurved).
- Matter and energy determine the curvature of spacetime.
- Spacetime expresses its nature through its geometric structure, with gravitational behavior

being one of its manifestations. Thus, gravitational behavior is not separate from spacetime but an integral part of how it is defined.

From the above discussion, it is clear that in general relativity, spacetime serves as the foundational mathematical framework—a four-dimensional geometric manifold. In this framework, gravity is not modeled as a force but as the curvature of spacetime itself. Once gravity is embedded in this geometric structure, **curvature becomes the only mathematically consistent way to represent gravitational effects**. Thus, general relativity treats gravity as an inherent property of spacetime—not something that acts within it.

However, if we look back to the period before general relativity was developed, we find that Einstein did not initially assume that gravity must be curvature. He was guided by the equivalence principle, which states: *"A gravitational field is locally indistinguishable from acceleration."* This insight was physically intuitive and led Einstein **to search for a deeper geometric formulation. Eventually, he geometrized gravity**—replacing traditional force-based thinking with a theory in which mass and energy determine the curvature of spacetime. Over time, this framework evolved to the point where curvature became the natural and consistent mathematical language for describing gravity.

But perhaps we should revisit where Einstein started—and return to common sense as well. In its earliest conceptual form, gravity in general relativity was associated with **acceleration**. This opens the door to an alternative interpretation: Can we

preserve the mathematical formulation of the Einstein Field Equations (EFE) while interpreting its variables differently? I believe we can.

While the standard interpretation equates gravity with spacetime curvature, an alternative view is to treat **spacetime as a field of acceleration**, and **curvature as the manifestation of gravity**. From this perspective, the EFE describe how gravitational behavior corresponds to changes in relative velocity—that is, to **acceleration**.

To illustrate this idea, consider a car increasing its speed from 100 mph to 200 mph. Traditionally, we interpret this as a change in velocity — that is, an acceleration requiring an applied force. However, from a relativistic perspective, it is possible to reinterpret the same outcome differently: as a change in the structure of spacetime, where space stretches and time contracts in such a way that the same physical effect is observed. This suggests that what we interpret as acceleration could equivalently be described as a geometric transformation of spacetime. According to the equivalence principle, the force we experience during acceleration is locally indistinguishable from the force we feel when resisting gravity. For example, an accelerating car requires force to change its velocity, just as a stationary observer on Earth requires a force (from the ground) to resist falling under gravity. Both are manifestations of relative acceleration — and in this interpretation, of the underlying geometry of spacetime.

Thus, rather than viewing gravity as a manifestation of curvature alone, we might view it as the **result of acceleration**.

Curvature then becomes a geometric encoding of gravitational effects that emerge from acceleration. This interpretation remains consistent with the equivalence principle, which equates local gravitational effects with acceleration, and it preserves the mathematical structure of the Einstein Field Equations.

Alternative Interpretation:

In this alternative interpretation of the Einstein Field Equations (EFE), spacetime geometry is understood not as a separate entity from acceleration, but as its mathematical representation—a structured map of how acceleration exists and behaves. Curvature in this geometry corresponds to the structure of acceleration itself, and gravity arises where that structure bends: sharper curvature in the acceleration field signals stronger gravity. The left-hand side of the EFE, which traditionally describes spacetime curvature, is thus reinterpreted as a contour of gravitational behavior emerging from acceleration. On the right-hand side, the distribution of mass and energy specifies how much geometric distortion appears in that acceleration-based structure. Altogether, the EFE become a statement that mass and energy correspond to a specific configuration of acceleration-based curvature in which gravity is embedded—tying together matter, acceleration, geometry, and gravity within a unified framework.

- Why This Is an Interpretation, Not a New Theory?

This reinterpretation of the Einstein Field Equations (EFE) is not a rejection of the existing mathematical framework of general relativity, nor does it propose new equations or mathematical structures. Instead, it offers a revised physical and philosophical understanding of what the existing mathematical terms represent. The standard interpretation asserts that mass

and energy curve spacetime, and that this curvature 'is' gravity. This view suggests that spacetime itself bends and changes—a concept that can be metaphysically and intuitively unsettling.

The acceleration-based reinterpretation takes a different stance: spacetime geometry spacetime isn't a thing that physically bends or stretches. Instead, it is a mathematical representation—a map—of how acceleration behaves in relation to the distribution of mass and energy. Gravity, in this view, is the manifestation of curvature within an acceleration field. This curvature does not imply that spacetime itself is changing, but rather that acceleration patterns are geometrically encoded. The EFE remain unchanged; only their physical meaning is reinterpreted.

- Response to Tensorial Modeling and the Role of Acceleration in Spacetime.

A natural critique of this reinterpretation may assert that acceleration is not fundamentally part of spacetime but merely an effect within it, or that acceleration is already modeled as a separate quantity in the Einstein Field Equations. This misses a critical point: acceleration is indeed fully modeled within the four-dimensional manifold of general relativity. The four-acceleration vector, defined as the covariant derivative of the four-velocity along a particle's worldline, is a tensorial object. It is computed using the metric and connection coefficients—core parts of the spacetime geometry itself. Therefore, acceleration is not something outside spacetime; it is mathematically embedded in it.

In fact, spacetime geometry already contains within it the full description of how objects accelerate, decelerate, and deviate from geodesic motion. What this reinterpretation does is flipping the perspective: instead of treating curvature as primary and acceleration as derivative, it treats acceleration as physically primary and curvature as a geometric representation of acceleration patterns.

Anyone arguing that acceleration is 'not part of spacetime' must contend with the fact that acceleration is modeled in covariant, tensorial form inside the very structure of general relativity's geometric framework.

5.2 Time

In this section, I am focusing on the reinterpretation of the temporal aspect of general relativity.

5.2.1 Gravitational Redshift

Clocks use a stable and precise periodic signal to measure time. Physicists utilize an atomic clock, a unique type of clock that uses the frequency of atomic transitions as a reference to generate a stable and precise periodic signal. The photons are involved in these atomic transitions because they are part of the electromagnetic radiation used to probe the atomic states, and their frequency is directly tied to the energy difference of the atomic transitions.

It is an empirical fact that when two atomic clocks are placed at different altitudes, the frequency of their atomic transitions differs due to the difference in gravitational potential. At higher altitudes—where the gravitational field is weaker and the potential is higher—atomic clocks tick faster, and their transition frequencies increase. Conversely, at lower altitudes, clocks tick more slowly. However, photons traveling through this gravitational gradient behave differently: a photon emitted at lower altitude and received at higher altitude appears redshifted—its frequency decreases—while a photon emitted from higher altitude appears blueshifted to an observer below. In this way, photon frequency and clock rate exhibit opposite behaviors when observed across differing gravitational potentials.

It seems that the main player in this physical phenomenon is the frequency – photon's frequency. Also, it seems that there is an "association" between gravitational field and frequency. This association is captured in Planck-Einstein relation as shown in (8).

$$E = hf \tag{8}$$

Such that E and f denote the photon's energy and frequency respectively whereas h is the Planck's constant. However, what does it mean if the photon's frequency has changed? We are going to offer a different interpretation shortly, without involving time-bending.

For both stationary and moving observers, the speed of a photon remains constant, as expressed in equation (9).

$$speed\ of\ a\ photon = \frac{distance}{time} \tag{9}$$

The "distance" in (9) can be replaced with wavelength λ of photons, representing the distance that one cycle of a photon can travel. Similarly, the time in (9) can be replaced with the time of one cycle of photon it can take, which is the period T. Therefore, (9) can be expressed in (10) as follow.

$$speed\ of\ a\ photon = \frac{\lambda}{T} \tag{10}$$

Now, as two photons that are placed at two different gravitational fields (or two different altitudes) will have two different periods – namely T_1 and T_2 –, two different energies – namely E_1 and E_2 –, and two different wavelengths – namely

λ_1 and λ_2. However, both photons will share the same speed which can be presented in (11).

$$speed\ of\ a\ photon = v = \frac{\lambda_1}{T_1} = \frac{\lambda_2}{T_2} \qquad (11)$$

From above relation we can establish this relationship:

$$\frac{\lambda_1}{T_1} = \frac{\lambda_2}{T_2} \qquad or \qquad \lambda_1 f_1 = \lambda_2 f_2 \qquad (12)$$

Both relationships (12) and (8) are sufficient to explain GTD. Thus, let us interpret every one of them separately before we merge both interpretations.

- Interpretation of (12)
    - To maintain a constant speed of a photon's wave, it must travel longer distances in a proportionally longer time, and vice versa. In other words, to maintain a fixed speed, a proportional decrease in a photon's wavelength must occur to offset any increase in frequency.
- Interpretation of (8)
    - A photon with higher energy will have a higher frequency, and vice versa.
- Combining (12) and (8)
    - Any change in a photon's frequency due to a change in gravitational field is accompanied by a corresponding change in its wavelength, in order to preserve the constant speed of light.

Now it's time to bring the above discussion together and connect the dots. Both atomic clock frequencies and photon frequencies are affected by gravity, but it is specifically the gravitational potential—not the strength of the gravitational field—that governs these changes. "Gravitational field" refers to the local strength of gravity—how strongly it pulls at a point—while gravitational potential reflects the relative position within the field, such as altitude above Earth's surface. At higher altitudes—where the gravitational potential is greater and the field is weaker—atomic clocks tick faster and photons are observed with higher frequencies. At lower altitudes—where the potential is lower and the field stronger—clocks tick more slowly and photons appear redshifted. Physicists interpret this difference in clock and photon frequencies as evidence of gravitational time dilation—the idea that time flows at different rates depending on gravitational potential. Moreover, to preserve the constant speed of light, any change in a photon's frequency must be accompanied by an inverse change in its wavelength. This shift in wavelength, when analyzed within the relativistic framework, is interpreted as a form of spatial contraction. Thus, what begins as a measurable change in frequency—whether in matter-based clocks or photons—is understood as a manifestation of how gravity alters both the flow of time and the geometry of space.

Physicists interpret the changes in a photon's frequency and wavelength in a gravitational field as more than just kinematic effects; they view them as direct indicators of how gravity alters the structure of spacetime itself. This interpretation is rooted in the framework of general relativity, where gravity is not treated as a force in the traditional Newtonian sense but as a

manifestation of spacetime curvature caused by mass and energy. In this view, a shift in photon frequency—when observed from a different gravitational potential—is not simply a change in the energy of the photon, but a signal that time is progressing at a different rate between the two locations. Similarly, the accompanying change in wavelength is not seen as a passive adjustment but as evidence that the spatial intervals themselves are being distorted by gravity. This geometric interpretation allows the theory to unify gravitational phenomena with the structure of space and time, making frequency shifts observable markers of deeper changes in the underlying fabric of reality.

Physicist's Interpretation:

Physicists interpret changes in photon frequency and wavelength in a gravitational field as evidence that gravity alters the very structure of spacetime. In this view, frequency shifts reflect time dilation, and wavelength changes indicate spatial contraction—both seen as consequences of spacetime curvature in general relativity.

Having already seen how physicists interpret gravitational time dilation—as the slowing of time and stretching of space due to curved spacetime—we must now ask whether such a framework is truly necessary to explain the observations. In my reinterpretation, the answer is no. Spacetime is not a physical fabric that deforms under the influence of mass and energy; it is a mathematical representation—a geometric map—of the gravitational acceleration field that arises from the presence and distribution of mass.

In my view, the variation in a photon's frequency or wavelength within a gravitational field is not evidence of time

slowing down or space being stretched. Instead, it reflects how the **gravitational field varies in strength and direction across space**, **and how that variation imposes real, physical changes on particles and signals passing through it**. The field's non-uniformity means that a photon moving from one region to another experiences a change in its energy. This is not because clocks run at different rates in different places, but because the field itself interacts with the photon, increasing or decreasing its energy depending on the local acceleration gradient it traverses.

The same reasoning applies to wavelength. A change in wavelength is not a contraction of space, but a consequence of the change in photon energy due to the local structure of the gravitational field. The field acts physically on the photon, and its structure—the way acceleration varies from point to point—is what gives rise to the observed redshift or blueshift.

Therefore, we are not observing spacetime deformation at all. We are observing the measurable influence of a real gravitational field acting on real particles. Once we understand that the field—and not a curved spacetime—is the true physical agent, there is no longer any need to invoke the geometric interpretation. The spacetime deformation model is not only unnecessary; it obscures the direct and physically grounded explanation: that all observed effects result from how photons and clocks respond to a non-uniform gravitational acceleration field.

Alternative Interpretation:

Gravitational time dilation and related effects reflect how photons and particles interact with a non-uniform gravitational field—there's no need to assume that time or space itself is deformed.

5.2.2 Viking Signal Delay (Shapiro Delay)

The Viking experiment measured the time delay of radio signals sent between Earth and Mars as they passed near the Sun. General relativity predicts that light will take longer to traverse a region near a massive object due to time slowing down in stronger gravitational fields. The time delay is given by[5]:

$$\Delta t = \left(-\frac{2GM}{c^3}\right) \ln \frac{r_E + r_M + R}{r_E + r_M - R} \tag{16}$$

Such that

- r_E and r_M are distances from the Sun to Earth and Mars, respectively, and R is their separation

Physicists interpret this as proof that time runs slower in strong gravitational fields—hence, light takes longer to travel through them.

Physicist's Interpretation:

In general relativity, signals take longer to propagate through regions of stronger gravitational potential because time progresses more slowly there relative to distant observers.

In contrast to the standard general relativistic explanation, which attributes the Shapiro delay to the curvature of spacetime and the slowing of time near a massive object, my

reinterpretation treats the phenomenon as a consequence of how gravity, understood as a real energy field, physically affects the propagation of the signal itself. Spacetime, in this view, is not a physical entity that bends or stretches but rather a mathematical framework—a geometric map used to represent the acceleration field generated by mass and energy.

When a radio pulse from a pulsar passes near its companion star, the traditional interpretation holds that spacetime is curved by the companion's mass, causing the light to follow a longer or "slower" path, even though it still locally travels at the speed of light. This interpretation relies on the idea that time itself flows more slowly in regions of stronger gravitational potential, and that the geometry of spacetime is altered in such a way that the delay arises naturally from the structure of the metric.

In my framework, however, the delay is not a manifestation of time behaving differently, but a direct physical outcome of the gravitational field acting on the signal. The gravitational acceleration associated with the companion star exerts a real influence on the motion of the pulse as it passes through the field. The resulting delay is due to the dynamic interaction between the pulse and the gravitational energy field—gravity slightly alters the speed or trajectory of the signal, not through the warping of time, but through the physical field's effect on the energy and momentum of the pulse.

The mathematical expression for the Shapiro delay, derived from general relativity, remains valid in form, because it effectively captures the influence of the gravitational potential on the signal. However, in this reinterpretation, the logarithmic

dependence on the geometry of the orbit is seen not as evidence of spacetime distortion but as a mathematical reflection of how gravitational acceleration influences the signal's passage. Time itself does not slow; rather, the signal takes longer to arrive because it interacts with a real, dynamic gravitational field that exerts measurable physical effects. This provides a consistent, alternative explanation of the Shapiro delay that dispenses with the metaphysical assumptions about spacetime and time dilation while preserving the predictive power of the underlying equations..

Alternative Interpretation:

The signal takes longer to arrive because it interacts with a real, dynamic gravitational field that exerts measurable physical effects.

5.2.3 Gravitational Time Dilation

Gravitational redshift refers to the phenomenon where electromagnetic signals (like light or radio pulses) emitted from a region deeper in a gravitational field appear **redshifted**—i.e., at a lower frequency—when observed from a region with a weaker gravitational field. This translates into the proper time difference between two observes in two different gravitational filed as follow [6].

$$\Delta\tau = \Delta t \sqrt{1 - \frac{2GM}{rc^2}}$$

Such that

- $\Delta\tau$: proper time

- Δt: coordinate time
- G: gravitational constant
- M: the mass causing the gravitational field
- r: the radial distance from the mass
- c: speed of light in vacuum.

In general relativity, gravitational redshift is interpreted as a direct consequence of **time dilation** due to spacetime curvature. They view t**ime flows more slowly** in stronger gravitational potentials (closer to mass), so an emitter deep in a gravitational well produces signals at a slower rate (from the point of view of a distant observer).

Thus, when a photon climbs out of the potential well, its **frequency appears lower** to a distant observer—not because it lost energy enroute, but because it was emitted from a region where clocks tick more slowly. Thus, the redshift reflects the difference in **proper time intervals** measured at each location.

Physicist's Interpretation:

In general relativity, a signal emitted from a stronger gravitational field appears redshifted to a distant observer because time runs more slowly at the source—this is gravitational time dilation.

In my view, the differences in observed signal frequency arise from how the gravitational field alters the energy and motion of the signal. A signal emitted from deep in a gravitational well must work against the gravitational field to reach the observer. As it climbs out, the gravitational field reduces its energy, which manifests as a lower frequency to the receiver—a real redshift due to field interaction, not relativistic

time differences. In other words, The signal **loses energy** in a measurable and physical way.

Alternative Interpretation:

When signals originate from regions with different gravitational fields, their frequency differences indicate that the gravitational field has physically altered the energy and motion of the signal—this effect does not arise from time dilation but from interaction with the gravitational field.

5.2.4 Relativistic time dilation

In special relativity, a clock moving at velocity v relative to an inertial observer appears to tick more slowly. This is captured by the Lorentz factor[6]:

$$\Delta\tau = \Delta t \sqrt{1 - \frac{v^2}{c^2}}$$

Such that

- $\Delta\tau$: the propter time. The time measured by a moving observer to light
- Δt: The time measured by a stationary observer to light
- v: velocity of the moving observer.
- c: speed of light in vacuum.

In binary pulsar systems, the pulsar's **orbital motion** causes its velocity to vary during the orbit. Also, near **periastron**, where the pulsar moves fastest, time dilation is greatest. Thus, this leads to a **delay in pulse arrival times** as measured by a

distant observer, called the **Einstein delay** (when combined with gravitational redshift). Thus, over the orbit, this leads to periodic variations in the observed pulse frequency due to both motion and gravitational potential. The result is a modulation in the observed signal frequency and timing, often described through the **Einstein delay**[6].

$$\Delta t_E = \gamma \sin u$$

Such that

- Δt_E: Einstein delay
- γ: a parameter incorporating both gravitational redshift and transverse Doppler shift.
- u: the eccentric anomaly of the orbit.

Thus, physicists treat this as a real change in the rate of proper time experienced by the moving clock (pulsar), purely due to its velocity.

Physicist's Interpretation:

The pulsar's changing orbital velocity leads to time dilation, causing its clock to appear to tick more slowly from the observer's frame

This idea plays a role in modeling pulse arrival times in binary pulsar systems, where the changing velocity of the pulsar leads to periodic variations in the observed timing of its radio pulses. In this view, the moving pulsar experiences a real, physical slowing of its internal clock, which is said to explain the shift in pulse frequencies observed from Earth. However, this interpretation conflates a mathematical construct with a physical effect. In my framework, **time dilation is not a real**

physical phenomenon. Instead, it is a result of how we must **mathematically adjust our calculations** to ensure that a key physical principle is preserved: the speed of light is constant for all observers, regardless of their relative motion.

Thus, the clock on a moving pulsar does not physically tick more slowly. It ticks normally in its rest frame. What changes is how we describe its ticking from a different frame of reference using mathematical transformations that preserve light-speed invariance. The observed variation in pulse arrival times is real, but it is better understood as a **kinematic effect** due to the pulsar's relative motion and changing light travel distance—not as evidence of actual temporal distortion.

The Einstein time delay captures an observable timing variation, but its significance is interpreted as a **propagation- and velocity-induced effect**, not due to time slowing. It reflects **how the motion affects the energy and emission frequency of the pulses** from an external viewpoint—not how the pulsar experiences time.

Any change in observed timing is due to the geometry of the orbit, the relative motion (causing Doppler-like shifts), or the gravitational interactions (already reinterpreted as energy effects, not time dilation).

This reinterpretation preserves the mathematical success of relativistic models while rejecting the metaphysical claim that time is malleable. It treats Lorentz transformations as necessary computational tools, not physical statements about the nature of time or the internal workings of clocks.

Alternative Interpretation:

In my reinterpretation, motion-based time dilation is not a real physical phenomenon but a mathematical artifact that arises when comparing observations from different frames of reference. The observed variations in pulse arrival times are real but are better understood as kinematic effects resulting from the pulsar's motion, changes in light travel distance, and field interactions—not as evidence of time flowing differently.

5.3 Space

This subsection examines two major phenomena involving the behavior of light in gravitational fields: starlight bending and gravitational lensing. These effects are widely regarded as strong confirmations of general relativity, where they are traditionally explained through spacetime curvature—specifically, the deformation of space and time in the presence of mass. Here, I focus on reinterpreting the spatial component of this deformation. Rather than attributing these effects to the curvature of space, I propose an alternative explanation: that gravity acts directly on photons, altering both their speed and trajectory, while space itself remains undistorted.

5.3.1 Starlight Bending

According to general relativity, light passing near a massive object like the Sun will bend due to the curvature of spacetime. The predicted deflection angle is [5]:

$$\delta_\theta = \frac{4GM}{c^2 b} \tag{13}$$

Such that:

- δ_θ: The total deflection angle of the light ray as it passes near the mass.
- G: The gravitational constant, $6.67430 \times 10^{-11}\, m^3 kg^{-1} s^{-2}$.
- M: The mass of the deflected object (e.g. the Sun), measured in kilograms.
- c: speed of light in vacuum.
- b: The impact parameter. The **closest distance** between the center of mass and the light ray's trajectory (in **meters**). For light grazing the Sun, this is approximately the **solar radius** $6.9634 \times 10^8\, m$

When Plugging in solar values in (13), it gives $\delta_\theta \approx 1.75$ arcseconds. Thus, the physicists interpret it as follow:

Physicist's Interpretation:

space itself curves near mass, and light simply follows the straightest path in that curved space—a geodesic.

In my interpretation, there is no need to imagine that space itself curves around massive objects. Spacetime is not a physical medium that bends or distorts—it is a mathematical map used to describe how gravitational acceleration varies across regions of space and time. The bending of starlight is not the result of a photon following a geodesic through curved space, but rather the outcome of a real, physical interaction between the photon and a non-uniform gravitational field.

As a photon passes near a massive object, such as the Sun, it moves through a region where the gravitational field is changing in strength and direction. This variation in the field

imparts a subtle but measurable shift in the photon's momentum, altering its trajectory. The deflection we observe is not caused by a deformation of space, but by the cumulative influence of gravitational acceleration acting on the photon as it traverses the field.

From this perspective, the observed change in the apparent position of a star during an eclipse is a direct consequence of field interaction—not a visual confirmation of spacetime curvature. The same bending angle predicted by general relativity can be derived by analyzing how photons respond to the structure of the gravitational field alone, without invoking geometric deformation. The curved spacetime model is a convenient mathematical encoding, but it is not necessary to explain what is fundamentally a field-driven redirection of light.

Alternative Interpretation:

Starlight bends near massive objects not because space is curved, but because the gravitational field redirects the photon's path through real, physical interaction.

5.3.2 Gravitational Lensing

Gravitational lensing refers to the bending of light from distant objects, like galaxies or quasars, as it passes near a massive foreground object. The basic deflection angle is again[5]:

$$\delta_\theta = \frac{4GM}{c^2 b} \tag{14}$$

The lens equation used to locate the lensed images is[5]:

$$\theta - \beta = \frac{D_{ls}}{D_s}\delta_\theta \quad (15)$$

Such that:

- θ: the observed image angle.
- β: the true angular position
- D_{ls}: the distance between the lens and the source
- D_s: the distance from the observer to the source.
- G: The gravitational constant, $6.67430 \times 10^{-11}\ m^3 kg^{-1} s^{-2}$.
- M: The mass of the deflected object (e.g. the Sun), measured in kilograms.
- c: speed of light in vacuum.
- b: The impact parameter. The **closest distance** between the center of mass and the light ray's trajectory (in **meters**). For light grazing the Sun, this is approximately the **solar radius** $6.9634 \times 10^8\ m$
- δ_θ: The total deflection angle of the light ray as it passes near the mass.

Physicists interpret the bending as light moving along curved spacetime, forming arcs, rings, or multiple images. This has been confirmed through observations of Einstein rings and multiple lensed images of the same object.

Physicist's Interpretation:

Physicists interpret gravitational lensing as the bending of light due to spacetime curvature near massive objects.

In my interpretation, the bending of light near massive objects does not require curved spacetime. Spacetime is not a physical entity that can warp or bend—it is a mathematical map used to describe how acceleration varies across space and time due to gravity presence. The phenomenon known as gravitational lensing arises not from geometry, but from how **real and physical gravitational fields** interact with photons as they travel.

As light from a distant source passes near a massive object, it moves through a **non-uniform gravitational field**. This field changes in strength and direction along the photon's path, resulting in a shift in the photon's momentum. These shifts are not caused by geodesics in curved space, but by the **acceleration gradients** of the gravitational field itself. The field alters the photon's trajectory in a way that depends on its position and direction of motion—just as a varying electric or magnetic field would alter the path of a charged particle.

The multiple images, arcs, magnifications, and time delays observed in gravitational lensing are therefore interpreted as consequences of **field-driven redirection**, not geometric distortion. Light takes different paths through differently structured regions of the gravitational field, and those paths reach the observer at slightly different times and angles. The lensing equations used in general relativity remain valid, but they are reinterpreted as representative tools, not as spacetime curvature.

In my view, the gravitational field acts like a transparent but structured medium that redistributes the directions and arrival

times of light rays. What we observe as lensing is the field's influence on photons—not a visual imprint of spacetime being bent or stretched. Thus, the concept of curved spacetime is unnecessary to explain lensing.

Alternative Interpretation:

Gravitational lensing occurs because light interacts with a non-uniform gravitational field—not because spacetime is curved.

5.4 Mass and gravity

This section turns to how general relativity describes the relationship between mass and gravity, particularly through the behavior of orbiting bodies and the influence of mass on their trajectories and rotational dynamics. In the standard framework, gravity is understood as a manifestation of spacetime curvature induced by mass and energy. This curvature governs how objects move, leading to observable effects that extend beyond simple Newtonian attraction.

Three central phenomena are examined in this section: **orbital decay**, **periastron advance**, and **frame dragging and spin precession**. Together, these effects form a vital observational pillar of general relativity, providing some of its most rigorous tests. This section explores how each phenomenon is modeled, measured, and understood within the standard theory—and sets the stage for **reexamining** what these effects reveal about the true nature of gravity and mass.

5.4.1 Orbital Decay

The orbital decay observed in binary pulsar systems refers to the gradual shrinking of the orbit over time. In general relativity, this is attributed to energy loss via gravitational wave emission.

The rate of change in orbital period $\dot{P}_b$ for a binary system (assuming an elliptical orbit) is given by [7]:

$$\dot{P}_b = -\frac{192\pi}{5}\left(\frac{2\pi G M_c}{P_b c^3}\right)^{5/3} \frac{1+\frac{73}{24}e^2+\frac{37}{96}e^4}{(1-e^2)^{7/2}} \frac{m_1 m_2}{(m_1+m_2)^{1/3}}$$

Such that

- $\dot{P}_b$: change in the decay of orbital period for a binary system for an elliptical orbit.
- P_b: orbital period
- m_1: mass of the first stellar
- m_2: mass of the second stellar
- e: orbital eccentricity
- G: gravitational constant
- c: speed of light in vacuum.

This result was derived by Peters & Mathews (1963) using the quadrupole formula for gravitational wave emission from an accelerating mass distribution. In practice, this formula accurately predicts the orbital decay of the Hulse–Taylor pulsar (PSR B1913+16) and the double pulsar (PSR J0737–3039A/B) to within a fraction of a percent.

In the standard view, physicists interpret the above orbital decay relationship as follows: when a binary system of massive bodies, such as neutron stars, undergoes accelerated motion, it emits gravitational waves. These waves are understood as ripples in the curvature of spacetime that propagate outward at the speed of light. Physicists believe that these waves carry away energy and angular momentum from the system. As a result, the orbit loses energy, causing the stars to gradually spiral inward and the orbital period to decrease over time.

The core idea in this view is that gravitational waves produce **real, physical distortions** of spacetime—they stretch and compress space and time itself as they pass. Since gravitational waves originate from energy and momentum within the system, the prevailing belief is that energy not only influences spacetime, but can **dynamically deform it** through wave-like propagation.

Physicist's Interpretation:

Physicists interpret orbital decay as evidence that accelerating massive bodies emit gravitational waves—ripples in spacetime that carry away energy and angular momentum, causing the orbit to shrink over time due to real distortions in space and time.

On the other hand, I have explained that spacetime is not a physical entity but merely a mathematical map of acceleration associated with gravity. Therefore, in my view, spacetime cannot be distorted. Instead, gravity is a real, physical field that transmits energy through space in a manner analogous to electromagnetic fields—but without invoking time dilation or spacetime curvature as physical phenomena. The gravitational

field itself can carry energy; thus, as the pulsars orbit, the system emits **gravitational field radiation**—not geometric curvature. This real radiation removes energy from the system, leading to orbital shrinking. When energy is transferred or lost from a system, a corresponding cost must be paid—in this case, orbital decay. This interpretation retains the same equations used in general relativity (such as the quadrupole formula), since they accurately describe the observable energy transfer. What changes is the physical meaning assigned to what is radiating and why.

Alternative Interpretation:
Orbital decay results from real energy loss through a gravitational field—not from spacetime distortion—making curved geometry unnecessary to explain the shrinking orbit.

5.4.2 Periastron Advance

Periastron is the closest point in the orbit of one celestial body around another, where the distance between the two is at its minimum. This term applies to any pair of objects bound by gravity, such as stars in a binary system, a planet orbiting a star, or a moon circling a planet. At periastron, the orbiting body moves fastest due to the stronger gravitational pull at shorter distances, following Kepler's laws of motion. The opposite point, where the two bodies are farthest apart, is called apastron. Periastron is a key concept in understanding orbital dynamics, influencing phenomena like tidal forces, energy exchange, and even the potential for collisions or mergers in extreme cases, such as with black holes or neutron stars.

In general relativity, the location of periastron advances with each orbit, meaning the ellipse slowly rotates over time. This effect is predicted by GR even in the absence of external perturbations (e.g., from other bodies)[7].

$$\Delta\omega = \frac{6\pi G(m_1 + m_2)}{a(1 - e^2)c^2}$$

Such that

- $\Delta\omega$: advance of periastron per orbit (in radians).
- a: semi-major axis of the orbit
- m_1: mass of the second stellar
- m_2: mass of the second stellar
- e: orbital eccentricity
- G: gravitational constant
- c: speed of light in vacuum.

In pulsar timing, periastron advance is measured in degrees per year and contributes directly to extracting system parameters like mass.

In general relativity, the shift in the closest point of an orbit—known as periastron advance—is attributed to the curved geometry of space and time around massive objects. The gravitational field, represented as curved spacetime, alters the paths of orbiting bodies in such a way that their trajectories are not closed ellipses, as predicted by Newtonian physics. This prediction was historically validated by explaining Mercury's anomalous perihelion advance and has been confirmed with high precision in binary pulsar systems. Thus, the standard

interpretation views periastron advance as a geometric consequence of moving through curved spacetime—a purely relativistic effect with no Newtonian analogue in the absence of external perturbations.

Physicist's Interpretation:

Periastron advance is understood as a geometric effect caused by motion through curved spacetime.

However, if we do not treat spacetime as a physical geometry, there is no need to interpret orbital trajectories as being curved by spacetime itself. As explained earlier, spacetime can be understood instead as a mathematical map of the acceleration associated with a gravitational field. The gravitational field, by contrast, is real and physical, and variations in it produce measurable dynamical effects—including periastron advance.

In this view, orbiting bodies experience a non-uniform and nonlinear gravitational field. Their trajectories shift not because of geometric curvature, but due to the inherent asymmetry and structure of the field itself. Just as electric or magnetic fields can cause precession in the motion of charged particles—without invoking curved space—a gravitational field with spatial and velocity-dependent structure can naturally produce orbital precession.

According to this reinterpretation, the standard formula for periastron advance is preserved. However, its meaning is redefined: the observed effect is a manifestation of the dynamics of the gravitational field, not the result of geodesic deviation in curved spacetime.

Alternative Interpretation:

Periastron advance results from the nonuniform gravitational field experienced by a body during orbital motion.

5.4.3 Frame Dragging and Spin Precession

In general relativity, a massive rotating object drags spacetime around with it. This is known as the Lense–Thirring effect or frame dragging. For a gyroscope or spinning pulsar, this dragging causes the spin axis to slowly precess.

For a spinning body orbiting a rotating central mass [6], the precession rate Ω_{LT} is:

$$\Omega_{LT} = \frac{2G}{c^2 r^3}\boldsymbol{J}$$

Such that

- Ω_{LT}: the precession rate.
- $\boldsymbol{J}$: angular momentum vector of the central rotating body.
- r: radial distance from the central mass
- G: gravitational constant
- c: speed of light in vacuum.

In binary pulsar systems, **spin-orbit coupling** and strong gravitational fields lead to an observable phenomenon called **geodetic precession** (or relativistic spin precession), where the **pulsar's spin axis precesses** over time. The precession rate can be measured through changes in the pulse shape and timing.

In the standard view, mass-energy and angular momentum curve spacetime, and the motion of spinning bodies through this curved geometry causes their spin axes to precess. This effect is interpreted as a direct consequence of spacetime being twisted by rotating masses—a phenomenon known as frame dragging. As a result, the spin axis of a rotating object, such as a pulsar, slowly changes direction over time, much like a gyroscope whose axis wobbles due to an external torque. In binary systems, this leads to observable variations in the orientation of the pulsar's magnetic axis, which can be detected as long-term changes in the pulse profile.

Physicist's Interpretation:

frame dragging causes a spinning object's axis to slowly change direction as it moves through twisted spacetime, resulting in measurable precession over time.

What if spacetime is not twistable—because it is not a physical medium, but rather a mathematical map of the acceleration field associated with gravity? In that case, frame dragging and spin precession must be explained in terms of real, physical interactions within the gravitational field itself, rather than as distortions of geometry. A rotating mass, then, does not twist spacetime but instead generates a **rotational component of the gravitational field**—analogous to how a moving electric charge produces a magnetic field.

A spinning object, such as a pulsar, moving through this structured field experiences a **real torque** due to its interaction with the field's nonuniform and velocity-dependent structure—not because it follows a geodesic in curved spacetime. Just as a

magnetic field causes a magnetic dipole to precess, a rotating gravitational field causes a spinning mass to precess. This is a **gravitational torque**, not a geometric deviation.

The mathematical model of spin precession (such as the Lense–Thirring effect) remains intact. What changes is the interpretation: the effect arises from **field dynamics**, not from the physical distortion of spacetime.

Alternative Interpretation:

Spin precession results from real torque within a rotating gravitational field—not from motion through twisted spacetime.

5.5 Mass and energy

This section focuses on how general relativity connects mass and energy to observable effects in astrophysical systems—particularly through the tools used to infer mass and system geometry from timing data. In the standard framework, the presence of mass and energy determines the curvature of spacetime, and this curvature in turn governs how signals and objects move. Observables like signal delays, orbital precession, and decay are treated as geometric consequences of the spacetime structure shaped by mass-energy.

Two key topics are examined here: **mass-energy inference** and **orbital inclination and geometry effects**. These are especially important in binary pulsar studies, where precise timing allows researchers to solve for unknown quantities—such as the masses of the stars and the angle of the orbit—by comparing measured effects to relativistic models.

Together, these topics show how mass and energy are tied to observable quantities within the general relativistic framework. This section reviews how those quantities are calculated and understood, and prepares the ground for **examining whether the same data can be fully explained within an alternative**, field-based model of gravitational influence.

5.5.1 Mass-Energy Inference

In binary pulsar systems, physicists infer the **masses of the two stars** (and related quantities) by fitting precise timing data to general relativistic models. These models incorporate several **post-Keplerian (PK) parameters** predicted by GR, such as:

- Periastron advance $\dot{\omega}$
- Gravitational redshift/time dilation γ
- Orbital decay $\dot{P}_b$
- Shapiro delay parameters (range r and shape s)

By simultaneously measuring multiple PK parameters and using GR equations, one can **solve for the individual masses** of the pulsars. As an example, if two PK parameters are measured precisely, GR provides two equations to solve for the two unknown masses m_1 and m_2. Additional PK parameters then serve as **internal consistency checks** for GR. These inferences depend on:

- The **metric** (spacetime curvature)

- The **geodesic structure** (how bodies and light propagate)
- The assumption that **mass-energy curves spacetime**

In the standard view, this predictive accuracy creates a tightly linked system among the following

1) **Mass and energy are interchangeable**, as captured by $E = mc^2$
2) Mass-energy acts as a **source of spacetime curvature**, via the Einstein field equations, which are already discussed in section 5.1.
3) Observables like periastron advance, Shapiro delay, and orbital decay **depend on how spacetime is curved** by mass-energy.

Therefore, the GR timing model assumes that measuring curvature effects reveals the underlying mass distribution. In this framework, the inferred masses are not just empirical—they are a reflection of how the geometry of spacetime responds to mass-energy.

Physicist's Interpretation:

Physicists infer mass and energy in binary systems by measuring how spacetime curvature—caused by mass—affects pulse timing and orbital dynamics.

In my interpretation, I retain the entire mathematical framework of general relativity but reject the idea that mass curves spacetime, since spacetime is not a physical entity.

Instead, mass produces a gravitational field—a real, physical field associated with acceleration—that is encoded mathematically in spacetime. The effects of this acceleration are experienced directly by bodies and signals.

All the post-Keplerian observables—orbital decay, Shapiro delay, periastron advance, and others—are interpreted as the result of bodies and light interacting with this gravitational field (or its associated acceleration), not as consequences of motion through curved geometry.

When timing data is used to infer mass, what is really being measured is how strongly the gravitational field influences motion and signals. The general relativistic equations still apply, but they are treated as **field equations**, not **geometric** ones. In this interpretation, we preserve the timing models and formulas, but we reinterpret them as describing how mass affects motion through field dynamics, not through spacetime deformation.

Alternative Interpretation:

Mass is inferred by observing how the gravitational field affects motion—not by measuring spacetime curvature.

5.5.2 Orbital Inclination and Geometry Effects

The **inclination angle** i of a binary pulsar's orbit describes the angle between the orbital plane and the observer's line of sight. It ranges from zero (face-on orbit) to 90 degrees (edge-on orbit).

They determine inclination using three items: Shapiro Delay, Pulse Arrival Timing, and Post-Keplerian Model Fitting.

For Shapiro Delay, they measure Shape parameter s and range parameter r and they produce precisely the measurement of **inclination angle** and companion mass. Such that $s = \sin(i)$ and it is measured directly from te timing residual due to the Shapiro delay. The range parameter is proportionally tied to the mass of the companion.

The pulse arrival delay caused by varying ligt travel distance (e.g. Roemer delay) depend on the orbit's orientation. Thus, Doppler shifts and redshifts timing signatures vary with inclination.

In Post-Keplerian Model, the inclination is a fit parameter in the relativistic timing model. Its value affects all relativistic timing corrections.

In the standard view, the orbital inclination is a real geometric orientation of the pulsar system within curved spacetime. General relativity predicts that several relativistic timing effects—such as Shapiro delay, time dilation, and gravitational redshift—depend explicitly on this orientation. The inclination also influences how light signals move through the gravitational field and how their arrival times vary. In this framework, the bending of spacetime, combined with the orbital geometry, affects how we observe the system, since the inclination angle is linked to how mass and curvature shape signal paths and timing.

Physicist's Interpretation:

orbital inclination affects how spacetime curvature influences signal paths and timing, shaping what we observe from Earth.

In my interpretation, spacetime is not a physical structure that bends or curves—it is a mathematical map of acceleration associated with the gravitational field. Therefore, orbital inclination is not a factor that changes how spacetime is curved, but rather how the **gravitational field interacts with light and matter along different lines of sight**.

The orbital inclination still represents a real geometric orientation of the system relative to the observer, but the **timing effects** we measure—such as Shapiro delay, redshift, and pulse arrival variations—are caused by how signals traverse the **acceleration field**, not by their motion through a distorted spacetime.

The equations used in general relativity to connect inclination, signal delay, and mass are still valid. What changes in my view is the **interpretation**: the variation in timing with inclination arises from differences in how signals interact with the gravitational field, not from how spacetime geometry distorts those paths. The inclination affects the projection of those interactions along our line of sight—not the curvature of space and time.

Alternative Interpretation:

Orbital inclination affects how signals interact with the gravitational field along our line of sight—not how they travel through curved spacetime.

5.6 Summary: Mass, Energy, Gravity, Acceleration, and Spacetime

In the traditional framework of general relativity, the behavior of binary pulsar systems—particularly the double pulsar—has been interpreted as a direct consequence of how mass and energy curve spacetime. Various observable phenomena, such as shifts in pulse timing and orbital dynamics, are explained through the lens of spacetime curvature, time dilation, and geodesic motion. In contrast, the reinterpretation presented here offers a conceptually different, yet mathematically consistent view. It treats spacetime not as a physical entity but as a mathematical map of the acceleration field produced by gravity, and it attributes all observable effects to real physical interactions with this field rather than geometric distortions.

In Summary, this reinterpretation preserves the predictive power of general relativity's equations but redefines the conceptual framework: time is not malleable, and spacetime is not a physical substance. Gravity is a field that generates real, measurable effects, and the mathematical tools we use—though developed within a geometric language—are seen as encodings of physical acceleration rather than geometric deformation. This offers a coherent and physically grounded alternative to interpreting one of the most precise experimental confirmations of general relativity.

6 PART D: EXPERIMENTS, REVISITED

The theory of general relativity has long been supported by a variety of experimental results that physicists commonly interpret as evidence for the physical deformation of spacetime. In this chapter, I revisit a select group of those experiments—not to disqualify their results, but to offer an alternative interpretation that aligns with the conceptual framework developed throughout this book.

This chapter does not attempt to provide a comprehensive review of all the experiments historically or currently associated with general relativity. Instead, I have chosen a few representative cases that are frequently cited as empirical confirmation of spacetime curvature. These include well-known phenomena such as gravitational time dilation, light deflection, and orbital precession. My goal is to demonstrate that these effects, while real and measurable, need not compel us to adopt the view that spacetime is physically malleable. Rather, they can be coherently understood as manifestations of gravitational field interactions and acceleration structures—without invoking the geometric deformation of a background continuum.

For readers interested in a broader survey of experimental tests of general relativity and the traditional interpretations they support, I recommend the article by K. J. Treschman, "Recent astronomical tests of general relativity," [1]. It offers a concise overview of both classical and modern tests, many of which continue to shape mainstream views on spacetime and gravitation.

6.1 Viking Relativity Experiment.

One of the most cited experimental confirmations of general relativity is the Viking relativity experiment, conducted in 1976 and published by Reasenberg et al. in 1979 [8]. This test was specifically designed to measure the **gravitational time delay** predicted by general relativity — an effect commonly referred to as the **Shapiro delay**. According to Einstein's theory, light (or any electromagnetic signal) passing near a massive object like the Sun experiences a slight delay in arrival time due to the curvature of spacetime. The Viking mission provided a rare opportunity to test this prediction with high precision using radar signals exchanged between Earth and a spacecraft on Mars.

- The Experiment and Its Findings

The Viking landers, stationed on the Martian surface, served as the endpoint for a sequence of precisely timed radio transmissions sent from Earth. As Mars and Earth orbited the Sun, there came a period during which the signal path between the two planets passed close to the Sun's limb. During this alignment, the radio signals were expected to experience a slight delay compared to what classical Newtonian physics would predict.

By carefully measuring the round-trip time of these radar pulses, and comparing the results to relativistic models, Reasenberg and his team confirmed a time delay in excellent agreement with the predictions of general relativity. Specifically, the experiment verified that the travel time of light is increased in the presence of a gravitational potential, with an accuracy of

about **0.2%**. The precision and cleanliness of the Viking measurements made this one of the strongest confirmations of general relativity up to that time.

- The Standard Interpretation: Spacetime Deformation

Within the framework of general relativity, the Viking results are typically interpreted as direct evidence that spacetime is **physically curved by mass and energy**. The logic follows from Einstein's field equations, which relate the energy–momentum content of the Sun to the curvature of the spacetime metric surrounding it. In this interpretation, the radar signals from Earth do not simply travel in straight lines through empty space; instead, they follow **null geodesics** — paths dictated by the curved geometry of spacetime.

From this viewpoint, the increased round-trip time observed in the Viking experiment arises because the signals are traveling through a **warped temporal and spatial fabric**. As the signal nears the Sun, both space and time are said to be stretched or distorted, causing the signal's effective trajectory — measured by coordinate time from Earth's frame — to lengthen. The curvature is not metaphorical; it is understood as a real, physical property of spacetime that influences the propagation of light and timekeeping processes.

This interpretation fits neatly within the geometric paradigm of general relativity and continues to be used in explaining gravitational lensing, satellite-based timing corrections, and other precision tests of relativity.

- My Reinterpretation: No Spacetime Deformation Required

The measurements and findings of the Viking experiment are fully accepted in this work. However, I aim to show how the results of the experiment can be understood within the interpretive framework developed throughout this book. While the standard view interprets the observed delay as evidence of a physically deformable spacetime, this is not the only way to understand the phenomenon. The same empirical result can be coherently described without invoking the notion that space or time physically bend or stretch.

Accordingly, the Shapiro delay observed in the Viking experiment is interpreted as a signal delay caused by the gravitational influence of the Sun. As the radar pulse travels through the Sun's gravitational potential, they are dynamically interacted, leading to a measurable delay. This delay is not the result of time itself being stretched, but of the signal's progress being modulated by the gravitational environment. The mathematical form of this effect remains consistent with general relativity's predictions, but the underlying physical explanation does not require a deformable spacetime.

- Conclusion

The Viking experiment remains one of the most precise and elegant confirmations of general relativistic predictions. However, its findings do not unambiguously mandate the interpretation that spacetime is a physically flexible entity. By reexamining the results through the lens of an acceleration structures, one can arrive at a consistent and empirically

equivalent explanation that preserves the predictive success of general relativity while challenging its metaphysical assumptions. The experiment measures a delay; what we make of that delay — whether we attribute it to the bending of spacetime or to the influence of a gravitational field on the propagation of light — depends on the interpretive framework we choose to adopt.

6.2 GPS Timing

The Global Positioning System (GPS) is one of the most widely known practical applications of relativistic physics [9]. As a satellite-based navigation system used worldwide, GPS must deliver positional accuracy within a few meters — a task that relies critically on the precise synchronization of atomic clocks aboard satellites and ground receivers. To maintain this synchronization, the system must account for relativistic effects predicted by both special and general relativity. Without these corrections, GPS measurements would accumulate errors of several kilometers each day.

This section examines how the relativistic corrections used in GPS calculations are typically interpreted within the standard framework of spacetime deformation and then shows how those same corrections can be understood within the interpretive model developed in this book.

- The GPS System and Its Relativistic Adjustments

GPS satellites orbit Earth at an altitude of approximately 20,200 kilometers and travel at speeds of around 3.9 km/s. Each satellite carries a highly stable atomic clock that

continually broadcasts time signals to receivers on Earth. These signals are used to triangulate position by comparing the time it takes for signals from multiple satellites to reach a single receiver.

However, these orbiting clocks do not tick at the same rate as clocks on Earth's surface. According to special relativity, the speed of the satellites causes their clocks to tick more slowly than clocks on the ground. At the same time, general relativity predicts that clocks in higher gravitational potentials — that is, farther from Earth's mass — tick more quickly than those in stronger gravitational fields. The combination of these two effects results in a net clock discrepancy: the satellite clocks tick **about 38 microseconds per day faster** than identical clocks on Earth.

This time difference, though small, is significant. Without correcting for it, positional errors in GPS would accumulate at a rate of over 10 kilometers per day. For that reason, relativistic time corrections are built directly into both satellite hardware and GPS signal processing algorithms.

- The Standard Interpretation: Spacetime Deformation

The conventional interpretation of these relativistic effects is rooted in the idea that spacetime is a physically malleable entity. From this perspective, the differing clock rates in orbit and on Earth arise because the satellites and receivers inhabit regions of spacetime that are physically shaped differently due to velocity and gravity. The Earth's gravitational mass is said to

curve the surrounding spacetime, stretching time near the surface and compressing it at altitude.

In this interpretation, the faster ticking of satellite clocks is not merely a function of gravitational influence or energy difference, but a manifestation of how time itself flows differently in regions of distinct spacetime curvature. Likewise, the slowing of satellite clocks due to motion is attributed to their worldlines slicing through spacetime at angles that alter their experience of proper time. The GPS system, in this view, functions correctly only because it compensates for these geometric deformations of time.

This interpretation is mathematically consistent with the predictions of relativity and has become the standard narrative used in physics education and technical literature to explain the role of relativity in satellite navigation.

- An Alternative Interpretation Without Spacetime Deformation

The findings of the GPS system are fully consistent with the interpretive framework developed throughout this book. The accuracy of the system and the need for relativistic corrections are not in question. What is reconsidered here is the physical meaning assigned to those corrections.

Rather than attributing the difference in clock rates to physical deformations in time or space, this framework understands them as consequences of gravitational and kinematic conditions encoded within a consistent mathematical structure. Spacetime is treated as a coordinate system — a map

— that tracks positions, velocities, and clock rates in a relational way, without implying that time itself is physically stretched or compressed.

From this perspective, the time discrepancy between satellite and ground-based clocks arises because the gravitational influence of Earth modifies how energy and motion affect ticking rates. The faster ticking of the satellite clocks is a result of being at a higher gravitational potential, where the energy cost to maintain a given frequency is different. The slower ticking due to motion follows from the relative kinetic energy between frames. These differences are captured in the same equations used in the standard relativistic model, but their interpretation does not require us to view spacetime as a dynamic medium.

The GPS system functions because these real physical effects — variations in clock behavior due to motion and gravitational potential — are precisely modeled and accounted for. Whether one chooses to describe these effects as changes in the fabric of spacetime or as differential clock behavior in a gravitational environment is a matter of interpretation, not a matter of experimental disagreement.

What this approach offers is a way to view the GPS corrections as rooted in real, measurable physical influences — not in the physical warping of time or space. The results remain identical, and the accuracy of the system remains fully intact, but the conceptual framing shifts away from a physically malleable spacetime toward a model that sees the timing

behavior of clocks as emerging from how they interact with energy, acceleration, and gravitational context.

- Conclusion

The success of the Global Positioning System in applying relativistic corrections is a powerful demonstration of the precision and utility of Einstein's equations. Yet it also illustrates how those equations — and the phenomena they describe — can be interpreted in different ways. The observed discrepancy in clock rates does not necessitate the conclusion that time itself is physically deformed. Instead, the difference can be understood as the result of real, context-dependent influences acting on clocks in distinct energy and motion environments. The GPS system, like the Viking experiment, stands as an example of how the interpretive framework developed in this book applies consistently to the most rigorous and practical tests of relativity.

6.3 Double pulsar experiment

Among the most precise and comprehensive tests of general relativity ever conducted is the study of the double pulsar system, known as **PSR J0737−3039A/B**. Discovered in 2003 and analyzed in detail by Kramer et al. in 2006 [10], this unique astrophysical system consists of two neutron stars orbiting one another, with both stars observable as radio pulsars. Their compact nature and close orbit, combined with the precision of pulsar timing, make this system a natural laboratory for testing gravitational theory under conditions of strong-field gravity and rapid orbital motion.

In this section, I will first describe the double pulsar system and summarize the major findings of the experiment. Then, I will present the standard interpretation used by physicists, which relies on the concept of spacetime deformation. Finally, I will show how these same results can be understood through the interpretative framework developed throughout this book, without requiring that spacetime itself be physically deformed.

- The System and the Findings

PSR J0737−3039A/B is located about 2,400 light-years from Earth. The two neutron stars orbit each other every **2.4 hours** in a mildly eccentric orbit. Because both stars emit radio pulses detectable from Earth, their motions can be tracked with exceptional precision. Over several years of observation, researchers measured five key relativistic effects, each one predicted by general relativity:

1. **Periastron advance** — The elliptical orbit of the pulsars rotates within the orbital plane, advancing by about **17 degrees per year**, consistent with relativistic orbital precession.

2. **Gravitational redshift and time dilation** — The timing of the pulses varies in a predictable way depending on the pulsars' position in the gravitational field of their companion.

3. **Shapiro delay** — The signal from one pulsar is delayed when passing through the gravitational field of the other, as expected from the influence of gravity on signal propagation.

4. **Orbital decay** — The orbit is gradually shrinking at a rate consistent with the energy lost through gravitational wave emission, as described by the quadrupole formula.

5. **Geodetic precession** — The spin axes of the pulsars precess over time due to their motion through the gravitational field of the companion.

All of these effects were observed with high precision and found to be in agreement with general relativity's predictions to within **0.05%**. No discrepancies were found, and the system continues to be monitored as a multi-aspect testbed for gravity theories.

- The Standard Interpretation: Spacetime Deformation

Within the conventional framework of general relativity, the findings from the double pulsar are interpreted as evidence for the curvature and dynamical nature of spacetime. Each of the observed effects is seen as a consequence of how massive bodies influence the geometry of spacetime around them.

In this view:

- **Periastron advance** arises because the pulsars move through a curved spacetime, causing their orbit to shift forward each cycle. The orbital path is no longer a fixed ellipse, but a slowly rotating curve shaped by the spacetime geometry.

- **Gravitational redshift** and **Shapiro delay** are attributed to how spacetime curvature affects time itself. The deeper one pulsar is in the gravitational potential of its companion, the more slowly time is said to pass, and signals traveling through that potential are delayed due to the stretching of spacetime.

- **Orbital decay** is explained as the result of energy carried away by gravitational waves, which ripple outward through the fabric of spacetime as it is dynamically deformed by the accelerating masses.

- **Geodetic precession** is described as the rotation of a spin vector within a curved and dynamic spacetime, analogous to how a gyroscope precesses in a gravitational field — but with spacetime itself supplying the geometry that dictates the effect.

In this interpretation, spacetime is not a static backdrop but a real, malleable entity whose curvature and dynamics directly influence the behavior of matter and light. The success of general relativity in predicting all five effects is taken as strong support for this view.

➢ Applying an Alternative Interpretation

The results observed in the double pulsar system are fully consistent with the interpretive framework developed throughout this book. The data and the mathematical predictions are not in question. What this section aims to show is that these same empirical effects can be understood without requiring spacetime to be physically curved or deformed.

From this perspective, the observed behaviors — such as orbital precession, timing delays, and orbital decay — are the result of real gravitational influences acting on the pulsars and the signals they emit. The mathematical structure of general relativity remains fully applicable, but the meaning assigned to its components is different. Instead of treating spacetime as a deformable physical entity, it is viewed as a coordinate system — a mathematical map — that tracks changes in motion, acceleration, and gravitational energy.

For example:

- **Periastron advance** can be interpreted as a consequence of the way gravitational influence modifies orbital motion through acceleration gradients. The rotation of the orbit results from cumulative, real dynamical effects, not a geometric distortion of the background.

- **Timing delays** observed in both gravitational redshift and Shapiro delay reflect how clock behavior and signal propagation are altered in a gravitational environment. These changes are governed by the varying acceleration conditions near each pulsar, rather than by any stretching or bending of time itself.

- **Orbital decay** is attributed to the loss of energy due to interactions within the gravitational field — modeled precisely by the quadrupole formula — without requiring spacetime to carry away energy as a physical medium.

- **Spin precession** is explained as a real rotational effect caused by the complex acceleration structure of the gravitational field surrounding the pulsars. The orientation of the spin vector changes over time due to these differential influences, not because the underlying spacetime is curved.

The mathematical predictions of general relativity — including the Einstein field equations and their solutions — continue to apply. The reinterpretation lies in how the results are conceptually framed. Gravitational effects are seen as arising from real, measurable interactions governed by energy and acceleration, not from the geometry of a physically flexible spacetime.

➢ Conclusion

The double pulsar system presents one of the most rigorous and multifaceted confirmations of relativistic physics to date. Its precision and complexity offer an ideal opportunity to apply the interpretive framework developed in this book. The observational data, the timing measurements, and the dynamical behaviors all align with the standard equations — yet they can be understood in a way that does not require us to treat spacetime as physically malleable. Instead, the results can be seen as consequences of how real gravitational influences shape the behavior of motion, timing, and interaction. In this light, the double pulsar experiment becomes not just a test of theory, but a demonstration of the broader applicability of a reinterpretation that preserves empirical accuracy while offering a different view of gravity's nature.

6.4 Li^+

One of the most direct and precise tests of special relativity's time dilation comes from experiments involving fast-moving atomic systems. In 2007, Reinhardt et al. conducted a highly controlled test using **highly charged lithium ions** accelerated to relativistic speeds [11]. The purpose of the experiment was to determine whether the time dilation predicted by special relativity would manifest with the expected precision in optical transitions, effectively treating these ions as moving atomic clocks. The outcome of the experiment confirmed the predictions of special relativity with extraordinary accuracy.

In this section, I first explain the experimental setup and summarize its findings. I then present the standard interpretation, which involves the deformation of spacetime. Finally, I apply the interpretive framework developed in this book to show how these same results can be understood without attributing physical change to time or space.

- The Experiment and Its Results

In the experiment, lithium ions were accelerated to about **34% the speed of light** and stored in a circular ring. These ions were stripped to a highly charged state and probed using two laser beams: one traveling in the direction of ion motion, and the other in the opposite direction. Each ion exhibited well-defined optical transitions—specific shifts in its internal energy levels—that could be measured with great precision. These transitions served as an internal "clock," ticking based on the ion's quantum behavior.

By comparing the observed Doppler shifts from both directions of the laser beams, the experimenters could isolate the effect of time dilation: the slowing down of the internal clock due to the ion's high speed. The results matched the Lorentz time dilation formula:

$$\Delta t = \gamma \Delta \tau$$

The ticking of the moving ion's clock appeared slower when compared to a clock at rest in the laboratory frame. Importantly, this effect was confirmed without ambiguity, and no deviation from special relativity was detected.

- The Standard Interpretation: Time Dilation as Spacetime Deformation

In the standard view, time dilation in this experiment is interpreted as a **real slowing of time** experienced by the fast-moving object. According to special relativity, spacetime is a unified, deformable structure. When an object moves at high velocity relative to a stationary observer, its trajectory through spacetime is altered—resulting in a slower accumulation of proper time. This is understood not simply as an observational discrepancy, but as a manifestation of a real geometric property: that time itself is physically "stretched" for the moving system.

Thus, in this interpretation, the lithium ion exists in a frame of reference where time progresses more slowly, not just from the viewpoint of an external observer, but in a physically meaningful sense. The experiment is seen as validating the idea that **motion causes time to deform**, as dictated by the spacetime structure encoded in the Lorentz transformations.

- Applying an Alternative Interpretation

The findings of the experiment are fully acknowledged in this work: the lithium ions indeed exhibited slower internal transitions, and the Lorentz transformations correctly predict the relationship between their frame and the laboratory frame. However, this section applies a different interpretation—one that does not require spacetime to be physically malleable.

In this setup, the lithium ions are **moving at high speed**, while their emitting source (the laboratory system that accelerates and probes them) remains **stationary**. From the perspective of a laboratory observer, the high-speed ion behaves in a way that increasingly **decouples** from the motion of its source. The ion's velocity appears not to be an extension of the emitter's motion, but instead takes on a kind of frame-independence—resembling, in some ways, the invariant behavior of light.

It is this **appearance of velocity independence from the emitter** that necessitates mathematical reconciliation. To relate the clock rates and spatial coordinates of the ion and its source frame, the Lorentz transformations are applied. But in this framework, those transformations are understood not as describing physical deformations of time or space, but as **mathematical adjustments** needed to reconcile the difference in velocities between the object and its emitter.

In other words, time does not physically slow down for the ion, nor is space contracted. Rather, the ion's apparent detachment from its source's motion leads to a situation where observers in the source frame must apply Lorentz

transformations to match what they observe in the ion's behavior. The observed time dilation is therefore a **mathematical artifact of reconciling different states of motion**, not a physical alteration of time itself.

This aligns with how Lorentz transformations were originally developed to explain the behavior of light—specifically, its invariant speed regardless of the motion of its source. For light, which is massless and lacks inherited momentum, velocity is entirely independent of emission. In the high-speed limit, massive particles like lithium ions begin to behave similarly, requiring the same sort of transformation not because spacetime deforms, but because our coordinate systems must reflect the increasing observational detachment between emitter and object.

- Conclusion

The lithium-ion experiment provides one of the clearest demonstrations of relativistic time dilation. It shows that high-speed motion leads to slower observed rates of internal processes—when viewed from a stationary frame. The conventional view explains this by invoking physical changes in the flow of time, rooted in spacetime deformation. But the same observations can be understood differently: not as consequences of time changing its physical nature, but as outcomes of how motion affects our relational descriptions between the source and the moving object.

As objects approach relativistic speeds, their motion appears increasingly **independent** of their source. This creates the need for **mathematical adjustments** between frames to

preserve consistency in observation. These adjustments, encoded in the Lorentz transformations, describe how observers reconcile the velocity gap between emitter and object—without implying that time or space itself is being physically altered. In this way, the lithium-ion experiment becomes yet another example where the empirical results of relativity remain intact, while their conceptual foundation can be reinterpreted without invoking a physically malleable spacetime..

6.5 Muon Experiment

The 1977 muon experiment conducted by Bailey et al. at CERN remains one of the most well-known and direct confirmations of special relativity[13]. By measuring the decay lifetimes of high-speed muons circulating in a magnetic storage ring, the researchers observed a dramatic extension of particle lifetime consistent with the Lorentz time dilation formula. This result has long been interpreted as evidence that time physically slows down for moving particles. In this section, I will describe the experiment, outline the prevailing interpretation, and then show how the same empirical findings can be understood through the interpretive framework developed throughout this book—without invoking spacetime deformation.

- The Experiment and Its Results

In this experiment, muons were produced through a cascade of particle interactions initiated in the laboratory frame. High-energy protons, each with a momentum of 3.1 GeV/c, were directed onto a fixed target. This collision generated fast-

moving pions traveling at approximately 99.8% the speed of light. These pions quickly decayed into muons, which inherited most of their parent particles' momentum.

The resulting muons were then injected into a magnetic storage ring, where they circulated in a circular path under the influence of a strong magnetic field. Muons are unstable particles, and their decay into electrons (or positrons) provides a natural internal clock that allows physicists to measure their lifetimes.

At rest, muons decay in about **2.2 microseconds**. But in the storage ring, the circulating muons exhibited a mean lifetime of approximately **64.4 microseconds**—nearly 30 times longer than the rest-frame value. This result precisely matched the prediction from special relativity using the Lorentz factor: $\gamma \approx 29.3$

This match between theory and observation has been taken as strong confirmation of relativistic time dilation: the idea that a moving clock runs more slowly relative to a stationary observer.

- The Standard Interpretation: Physical Slowing of Time

Within the conventional framework of special relativity, the extended muon lifetime is interpreted as a physical manifestation of time dilation due to motion through spacetime. According to this view, the muons are moving at such high speeds that their progression through time itself is slowed relative to the laboratory frame. This is not understood

as a mere artifact of measurement or perspective, but as a real change in the rate at which time flows for the particle.

In geometric terms, the muon travels along a worldline through spacetime that causes its proper time to accumulate more slowly compared to that of an observer in the laboratory. The Lorentz transformation is thus taken as more than a mathematical tool—it is interpreted as a window into the actual physical behavior of time under motion. The muon's decay is delayed not because we are looking at it differently, but because its internal processes genuinely slow down in a spacetime affected by velocity.

This interpretation is embedded in most presentations of special relativity and is used to explain particle lifetime extensions, clock discrepancies in high-speed systems, and even corrections in satellite-based technologies.

- Applying an Alternative Interpretation

The findings of the muon experiment are not in question here. The extended lifetime is real, measurable, and consistent with the Lorentz transformation. What differs in this section is how we choose to interpret the origin of that effect.

Let us begin with a structural understanding of the setup. The muon is not emitted in the traditional sense—it is not launched by a moving source. Rather, it is created through the **decay of a fast-moving pion**, which itself was produced by colliding stationary-target protons in the lab frame. This chain of events—initiated in a laboratory-based system—means that,

although the muon inherits high velocity, the overall system that gave rise to its motion originates from a **stationary frame**.

This matters because it creates a specific observational condition: the muon's velocity **seems** to exist independently of the emitting source's speed, which is stationary. This mimics a key feature of how we understand light: the velocity of a photon is also independent of the motion of its source. In the case of the muon, this decoupling is not due to its being massless—it is not. But kinematically, the muon's behavior now resembles that of light in one critical way: its speed is **not carried by or anchored to** its emitter, due to the higher speed difference.

This observational asymmetry justifies the use of the **Lorentz transformation**. However, in the framework developed throughout this book, Lorentz transformations are not understood as revealing a deformation of time. Instead, they are **mathematical adjustments**—recalibrations—used to reconcile vastly different frames of motion: in this case, a nearly stationary frame of origin and a particle traveling near the speed of light.

When applied to this situation, the Lorentz transformation allows us to rescale the time variable to align the observations from the stationary lab frame with the behavior of the fast-moving muon. The resulting time dilation is **real in its consequences**, but it is not the outcome of time physically slowing down. It is a recalibration of the frame needed to properly describe the motion of an object whose speed appears **inertially detached** from its origin.

Time appears to slow down not because time itself is being stretched, but because our stationary frame must rescale its measures of time and space to **accurately model the behavior** of a particle moving with near-light-speed detachment from its origin. The math is valid. The decay extension is measurable. But time is not deforming.

- Conclusion

The muon experiment powerfully validates the predictive accuracy of special relativity. But like other high-speed experiments, it also provides an opportunity to reflect on what the results mean. While the standard interpretation frames the extended muon lifetime as proof that time physically slows under motion, the same result can be seen through a different lens.

When a particle travels so fast that its velocity appears **independent of the source that produced it**, the observed behavior must be reconciled using Lorentz transformations—not because time has changed in nature, but because our frame of reference must be rescaled to represent that behavior faithfully. The lifetime extension of the muon is thus a **mathematical consequence of extreme velocity mismatches**, not a deformation of time itself.

This interpretation preserves the empirical success of relativity while offering a different understanding of what time dilation actually describes. The muon experiment stands as a compelling example of how even the most rigorous relativistic confirmations can be coherently understood without invoking a physically malleable spacetime.

6.6 Hafele and Keating experiment

A widely cited experiment conducted in 1971 involved flying atomic clocks aboard commercial aircraft—once eastward and once westward around the globe—with the goal of testing relativistic time dilation predictions [14], [15]. The authors concluded that the discrepancies observed between the airborne clocks and reference clocks on the ground constituted direct empirical support for Einstein's theory of relativity.

While the experiment was pioneering in its ambition, I argue that the data it produced are not sufficiently reliable to draw such strong conclusions. Several technical and methodological limitations cast doubt on the validity of the findings and warrant a re-examination of their significance.

A primary concern is the known performance limitations of atomic clocks in the early 1970s. Even under laboratory conditions, cesium-beam atomic clocks of that era could drift from one another by as much as 1 microsecond per day. Worse still, this drift was not constant. It fluctuated unpredictably, making it difficult to distinguish between internal clock error and the time discrepancies predicted by relativity. The experimenters acknowledged this challenge and attempted to compensate for it by averaging the long-term behavior of the clocks used. However, only four clocks were employed during the flights—a sample size that is inadequate for meaningful statistical confidence.

This shortcoming was candidly admitted by the authors themselves, who noted:

"*The number of measured values is too small for a good statistical analysis*" [14].

Although statistical methods were used to adjust for drift and instability, the final reported uncertainty remained substantial. As the authors wrote:

"*The product of this rate uncertainty with the duration of the trips gives an estimated final error of less than 30 nanoseconds, which is about three times the standard deviation and probably represents an overestimate*" [14].

Further experimental weaknesses include the lack of correction for ambient environmental factors such as temperature and pressure, both of which are known to affect atomic clock performance. While these influences were acknowledged, they were not fully accounted for in the data analysis.

Criticism from experts in the field further supports the need for caution. Louis Essen, the designer of the cesium-beam clocks used in the experiment, publicly stated that the devices lacked the precision necessary to test relativistic predictions[3], [16]. In addition, G. B. Malykin provided a detailed methodological critique, writing:

"*From the methodology viewpoint, the experiments performed by Hafele and Keating … are far from being flawless*" [17].

---

[3] We could not verify the reported statement from the original source because it couldn't be found in the libraries.

Malykin specifically pointed out that while the authors corrected for the airplane's average speed, they did not perform proper time integration over variations in velocity, which is essential since time dilation scales quadratically with instantaneous speed. He emphasized:

"*When it is allowed for, one cannot use only the average velocity of the airplane; time integration should be performed to take into account variation in the airplane velocity*" [17].

He also noted several additional sources of systematic error that were overlooked, including the gravitational effects of terrain elevation, free-air correction, latitude variation, the Earth's mass distribution, and the varying density and thickness of the Earth's core.

Beyond these foundational issues, several broader concerns further challenge the reliability of the Hafele–Keating experiment as definitive proof of relativistic time dilation.

First, the experiment suffers from a lack of **experimental repeatability**. Despite its historical prominence, the exact procedure has not been replicated under identical conditions using modern atomic clocks and independent verification protocols. Given the central claim—that relativistic effects were observed in a real-world aviation context—such an absence of follow-up replication underlines the fragility of the original findings.

Second, there was **no real-time synchronization** between the airborne and ground-based clocks during the flights. All clock comparisons were made post-flight, meaning that any

disturbances, drifts, or hardware instabilities that occurred mid-flight went undetected. This introduces a layer of uncertainty that modern timekeeping standards would not overlook.

Third, the experiment attempted to test both **special** and **general relativistic effects simultaneously**: time dilation from motion (special relativity) and gravitational time shift from altitude (general relativity). However, these effects were not decoupled or independently controlled. Without isolating one from the other, the observed net time differences become ambiguous and prone to alternative interpretations, especially given the scale of the predicted effects relative to the measurement noise.

Taken together, these additional concerns further erode the claim that the Hafele–Keating experiment constitutes strong empirical validation of relativistic time dilation. Its pioneering nature is not in question, but its scientific rigor—as judged by modern standards—leaves much to be desired. The combination of limited instrumentation, methodological compromises, and under-addressed sources of error suggest that the experiment's conclusions should be viewed as tentative, not definitive.

In summary, although the Hafele–Keating experiment broke new ground in testing relativity outside the laboratory, its results fall short of providing conclusive evidence for relativistic time dilation. The limitations in instrumentation, statistical treatment, environmental control, and physical modeling render the findings suggestive at best. A modern reevaluation using today's more precise and stable atomic clocks, along with

improved methodology, would be necessary to definitively validate or refute the original conclusions.

6.7 Gravity Probe A (GP-A) mission experiment

The **Gravity Probe A** experiment [18], led by Vessot et al. and launched in 1976, provided one of the earliest and most precise tests of **gravitational redshift**, a key prediction of general relativity. By sending a highly stable hydrogen maser clock into space aboard a rocket and comparing its ticking rate with an identical ground-based clock, the experiment offered a clean, direct observation of how gravity affects timekeeping.

In this section, I will describe the experiment and its findings, present the standard interpretation grounded in the concept of spacetime deformation, and then show how the same empirical results can be understood within the interpretative framework developed in this book—without requiring that time or space undergo any physical alteration.

- The Experiment and Its Results

Gravity Probe A involved launching a hydrogen maser atomic clock aboard a suborbital rocket to an altitude of approximately **10,000 kilometers** above Earth's surface. This high-altitude clock, experiencing a **weaker gravitational potential**, was then compared in real time to a matching hydrogen maser clock that remained on Earth.

According to general relativity, a clock located farther from a massive body should tick faster than one located deeper in the gravitational potential well. This is a direct consequence of what

is commonly known as **gravitational time dilation**. The fractional frequency shift expected between the two clocks, according to general relativity, is given by:

$$\frac{\Delta f}{f} = \frac{\Delta U}{c^2}$$

Where ΔU is the difference in gravitational potential between the two clocks, and c is the speed of light.

The experimental results matched this prediction to within **1.4 parts in 10^4**, confirming the expected gravitational redshift with remarkable precision. The spaceborne clock ticked measurably faster than the one on Earth, and the difference precisely corresponded to the gravitational potential difference.

- The Standard Interpretation: Time Slows in a Warped Spacetime

In the standard interpretation, this result is understood as a **physical consequence of spacetime curvature**. According to general relativity, massive objects like Earth deform the geometry of spacetime around them. This deformation includes both spatial curvature and a warping of the time dimension.

In this view, the onboard clock ticked faster not merely as a result of a potential difference, but because **time itself flows differently at different positions within a curved spacetime**. The clock in the rocket was situated in a region where the curvature of spacetime was shallower; therefore, the flow of time was less "stretched" compared to the clock deeper in the gravitational well.

The mathematical expression of this effect is derived from the Schwarzschild solution to Einstein's field equations. There, the time component of the spacetime metric changes as a function of radial distance from a mass, resulting in different rates of time passage for clocks at different altitudes.

This interpretation has been widely accepted and forms the foundation of how relativistic time corrections are applied in satellite technologies such as GPS. It is commonly taught that clocks run slower in stronger gravitational fields because the fabric of spacetime is curved, and time is one of the dimensions being physically stretched.

- Applying an Alternative Interpretation

The Gravity Probe A experiment provides a compelling opportunity to apply the interpretative framework developed throughout this book. The empirical data are accepted in full: the clock at higher altitude ticks faster, and the magnitude of this shift is accurately predicted by the relativistic equations. What is reconsidered here is not the mathematical formulation, but the physical meaning we assign to it.

Rather than interpreting the difference in clock rates as the result of **time itself being physically warped**, this framework treats the situation as a comparison of **how physical systems behave under different gravitational conditions**, without altering the nature of time as a dimension.

In this view, gravitational redshift is not the result of clocks residing in regions where time flows faster or slower. Instead, it reflects how **gravitational potential influences the energy**

levels and ticking behavior of physical systems. The onboard hydrogen maser clock is subject to different gravitational conditions than the ground-based one, and this results in a shift in its frequency. But this shift is not due to a physical deformation of time—it is due to how the gravitational environment modifies the clock's operational behavior.

The equation:

$$\frac{\Delta f}{f} = \frac{\Delta U}{c^2}$$

remains entirely valid. The potential difference ΔU still governs the frequency shift. But the interpretation is that **the gravitational potential alters the clock's behavior**, not the structure of time. Time itself remains an abstract and uniform parameter within a coordinate system, used to track relationships between events. The gravitational redshift is a physical effect arising from changes in gravitational energy, not from spacetime stretching.

The Earth's gravitational field modifies how systems evolve over time—not because time itself changes, but because the systems are physically responding to their environment. The frequency shift we observe is real and measurable, but it reflects **how matter behaves in gravitational fields**, not how time itself is bent or deformed.

- Conclusion

Gravity Probe A stands as a historically significant and technically elegant test of general relativity. It confirmed the

gravitational redshift effect with exceptional accuracy, demonstrating that clocks at higher altitudes tick faster than those at lower altitudes. The conventional interpretation views this as direct evidence that time itself is affected by spacetime curvature.

However, this experiment can also be understood differently. The measured frequency shift is not necessarily a deformation of time, but a real, measurable change in how physical systems behave under differing gravitational potentials. The mathematics remains untouched, and the predictions remain correct—but the underlying interpretation shifts.

Rather than invoking a physically malleable spacetime, this framework sees gravitational redshift as the result of a system's energetic and environmental context. Clocks tick differently not because time flows differently, but because gravity affects how they operate. In this way, the Gravity Probe A experiment becomes another case in which relativistic predictions are fully compatible with an interpretation that does not require the deformation of space or time.

6.8 Pound and Rebka Experiment

One of the earliest direct confirmations of general relativity's prediction of gravitational redshift came not from deep space or orbiting satellites, but from a carefully designed laboratory experiment conducted at Harvard University. The **Pound–Rebka experiment** [19], [20], first reported in 1960, measured the tiny frequency shift of gamma-ray photons moving through Earth's gravitational field over a vertical distance of just over 22 meters. Despite its modest scale, the

experiment demonstrated the gravitational influence on photon frequency with remarkable clarity, becoming a foundational result in the study of relativistic gravity.

In this section, I explain the design and findings of the experiment, present the standard interpretation grounded in spacetime curvature, and then apply the interpretative framework developed throughout this book to show how the same results can be understood without requiring any physical deformation of time or space.

- The Experiment and Its Results

Pound and Rebka used the **Mössbauer effect**, which allows for the emission and absorption of gamma-ray photons without recoil, making extremely precise frequency measurements possible. A source of 14.4 keV gamma photons from iron-57 was placed at the top of Harvard's Jefferson tower, and an absorber of the same isotope was placed at the bottom, about **22.5 meters** below.

According to general relativity, photons moving **downward** in a gravitational field should be **blueshifted**—gaining energy as they fall—while those moving **upward** should be **redshifted**, losing energy. The expected fractional frequency shift is:

$$\frac{\Delta f}{f} = \frac{\Delta U}{c^2} = \frac{gh}{c^2}$$

where g is Earth's gravitational acceleration, h is the height difference, and c is the speed of light.

To detect the tiny shift, the absorber was moved back and forth with a known velocity to produce a **Doppler shift** that would counteract the gravitational shift. The speed needed to cancel the frequency difference between emission and absorption matched the relativistic prediction with an uncertainty of about **1%**, later improved in follow-up measurements.

This confirmed that photon energy is affected by gravitational potential, even over short distances, as predicted by general relativity.

- The Standard Interpretation: Spacetime Curvature and Time Flow

In the conventional view, the Pound–Rebka experiment provides direct evidence that **time itself flows differently** in different gravitational potentials. Within general relativity, spacetime is not a fixed backdrop but a curved, dynamic entity influenced by mass and energy. In a gravitational field like Earth's, the geometry of spacetime is said to be warped such that **clocks run more slowly at lower altitudes** compared to higher ones.

The frequency shift in this interpretation is seen as the manifestation of that warping. A photon emitted at a higher gravitational potential carries the imprint of a faster-ticking clock. As it travels downward to a region where time is flowing more slowly, it appears to gain energy—or equivalently, be blueshifted—because the receiving system's notion of time is different.

Thus, the gravitational redshift is treated as a geometric phenomenon. The passage of time itself is understood to stretch or compress depending on one's position in the gravitational field, and the photon's frequency shift is interpreted as a direct probe of this differential flow of time.

- Applying an Alternative Interpretation

The empirical outcome of the Pound–Rebka experiment—the precise and predictable shift in photon frequency over a gravitational potential—is not in dispute here. What is reconsidered is how we interpret that outcome.

In this framework, time is not viewed as something that flows more slowly or quickly depending on position in a gravitational field. Instead, time remains a coordinate—part of a consistent framework used to describe events and processes. The observed redshift is not taken to mean that time has physically stretched or slowed, but rather that **photon energy and frequency are influenced by the gravitational potential** through which the photon moves.

From this perspective, the gravitational potential modifies the **energy state** of the photon as it travels through the field. When a photon climbs upward in Earth's gravitational field, it loses energy, not because time is deforming, but because **energy is required to overcome the gravitational potential difference**. Conversely, a photon falling downward gains energy for the same reason. This change in energy manifests as a change in frequency—just as it does in classical systems.

The equation:

$$\frac{\Delta f}{f} = \frac{gh}{c^2}$$

still applies. But the shift in frequency is understood as a direct result of **how energy conservation and gravitational interaction** affect photon behavior—not of a variable rate of time. The clocks at different altitudes are not ticking at intrinsically different speeds because time itself is stretched; rather, the systems within those gravitational environments evolve differently because of their interaction with the field.

In this view, the redshift is not telling us something about time being physically warped. It is telling us something about **how light, energy, and physical systems respond to gravitational conditions**, and the Lorentz-based description offers the necessary mathematical structure to describe these effects. But the physical interpretation remains grounded in energy dynamics—not spacetime deformation.

- Conclusion

The Pound–Rebka experiment elegantly demonstrated that gravitational potential affects photon frequency. It was the first laboratory-scale test of general relativity's prediction of gravitational redshift and remains a powerful confirmation of the theory's predictive accuracy.

The standard interpretation sees this as evidence that time flows differently at different heights due to spacetime curvature. However, the same observations can be understood differently: not as a result of time deforming, but as a consequence of how photons exchange energy with their gravitational environment.

The frequency shift is real and measurable, and the relativistic equation describing it remains valid. What changes in this interpretation is the **meaning assigned to the result**: energy is changing, not time. The photon's frequency responds to gravitational potential, not because time itself has warped, but because energy conservation and field interaction require it. The experiment thus becomes another case where the mathematics of relativity remains intact, but the conceptual understanding can be reframed without invoking the physical deformation of spacetime.

.

7 PROPOSED EXPERIMENT

7.1 Addressing the "Philosophical" Criticism

Throughout this book, I have proposed a reinterpretation of the theory of relativity that preserves the mathematical structure and predictive power of special and general relativity, while offering a different understanding of what the equations mean. In this reinterpretation, phenomena such as time dilation, gravitational redshift, and spacetime curvature are understood not as literal deformations of time or space, but as the result of physical processes like energy distribution, acceleration, and gravitational interaction—mapped mathematically through geometric frameworks.

This approach has occasionally been labeled "philosophical" by critics who argue that, because it does not currently predict new experimental outcomes, it offers no empirical distinction from the standard view. However, this criticism rests on a misunderstanding of what this reinterpretation seeks to achieve. **The goal has not been to replace existing predictions but to clarify the conceptual foundation beneath them.** That said, the desire to make this reinterpretation empirically testable is – although not valid – a meaningful direction.

7.2 Designing a Test for This Reinterpretation

To move this discussion from the conceptual into the experimental domain, I now propose an experiment that could offer a direct empirical distinction between the standard interpretation of relativity and the reinterpretation developed in

this book. This proposal is rooted in a subtle but critical feature of the reinterpretation: that the appearance of time dilation arises not merely from velocity, but from whether an object's motion appears **kinematically detached** from its emitter.

In the standard interpretation of relativity, time dilation depends solely on the relative velocity between frames, regardless of how that velocity was produced. In contrast, my reinterpretation suggests that time dilation becomes necessary **only when** an object's velocity appears **independent** of its emitter—similar to how the speed of light behaves. If the object's motion remains clearly tied to its emitter, then the need for Lorentz rescaling may be diminished or even absent.

This experiment is therefore designed to test whether **the emitter-object kinematic relationship** plays a role in determining the presence or absence of time dilation.

7.2.1.1 Objective

To determine whether the **mechanism by which high-speed massive particles acquire their motion**—whether detached or attached to their emitter—affects the degree of observed time dilation.

While the experiment proposed in this chapter focuses on a specific feature of special relativity—the application of the Lorentz factor in linear motion—the reinterpretation developed in this book extends far beyond that. Testing this narrower case may be the first step toward examining the broader implications of this reinterpretation—extending eventually into how we model gravity, geometry, and energy throughout the cosmos.

7.2.1.2 Test Principle

The experiment contrasts two scenarios:

- **Test A (Kinematically Detached Motion):** A massive particle is emitted with a velocity that is **much greater than the velocity of its emitter**. In this case, the object's motion appears detached from its origin—similar to how light behaves independently of its source. In my view, this detached nature justifies applying the **full Lorentz rescaling** to compare time between observers.

- **Test B (Kinematically Attached Motion):** A massive particle is emitted with a velocity that is **comparable to the velocity of its emitter**. Here, the motion appears linked to its source. I hypothesize that this case may **not (or nearly) require** Lorentz rescaling between observers moving with the emitter and those at rest in the lab.

If both particles move at the same speed relative to the lab, but only the detached-motion case exhibits full time dilation, this would confirm that the Lorentz factor is not merely a function of speed—it depends on whether the object's motion appears **source-detached or source-bound**.

7.2.1.3 Key Conditions

- **Massive Objects Only:** This experiment applies exclusively to **massive particles**. Massless particles, like photons, are always source-detached and always require Lorentz rescaling in all interpretations. They do

not provide a meaningful test here. Both particle groups—detached and attached—must consist of **massive particles** such as ions, electrons, or neutral atoms.

- **No Decay-Based Sources:** To preserve a clean conceptual distinction, both particle types must result from **emission**, not **decay**. In physics, both emission and decay involve the release or transformation of energy and particles, but they differ in their origin and behavior. **Emission** typically refers to the release of a particle or wave from a system due to an external trigger or internal excitation. For example, when a gun fires a bullet, the bullet is emitted due to a sudden force, and it begins moving with a velocity determined by that force. Similarly, atoms emit photons when electrons drop to lower energy levels. In such cases, the emitted particle acquires momentum—but this momentum is imparted during the act of emission and often originates from an external or internal energy source acting on the system. **Decay**, on the other hand, is a spontaneous process in which an unstable particle or system transforms into more stable components. If a moving particle decays into two or more products, those products must share the momentum and energy the original particle carried. In this case, momentum is conserved: the decay products inherit and redistribute the total momentum of the parent particle according to conservation laws. In short, **emission is an active process often driven by a force or transition, while decay is a passive transformation governed by**

intrinsic instability. Both result in particles with momentum, but the source and conservation context differ. Decay-based motion (such as muons from pion decay) cannot be used in the actual experiment.

- **Force Symmetry:** The environment must cancel or match **all forces** (gravitational, rotational, inertial) acting on both particle groups. For example, if one group travels in a storage ring, the other must experience the same rotational path and centripetal force. Alternatively, both groups can be placed on identical linear tracks in microgravity or neutral-force environments. This is essential to eliminate **contamination from gravitational or rotational time dilation** predicted by general relativity.

7.2.1.4 Experimental Design

Compare two groups of massive particles:

1. **Detached-motion group:** Particles emitted from a system moving much slower than the particles themselves. For example, neutral atoms launched at relativistic speeds from a low-speed emitter.

2. **Source-attached group:** Particles accelerated from rest in coordination with their emitter system—for instance, ions accelerated from a lab platform that co-moves with the observer.

- **Same final speed:** Both groups are brought to the same final velocity (e.g., 0.999c) relative to the lab.

- **Same trajectory:** They travel through identical spatial paths under matched conditions.
- **Time comparison:** Their internal "clocks" are compared using either decay timing (if compatible) or transition frequencies (e.g., atomic clocks).
- **Frame of reference:** Time measurements are evaluated from the **lab frame**, where the emitter-object relationship is visible and meaningful.

7.2.1.5 Theoretical Expectation

- **Standard interpretation:** Time dilation must be identical in both tests, since the particles have the same velocity relative to the lab.
- **My reinterpretation:** Time dilation will occur **only** in Test A. In Test B, where the particle's velocity appears inherited from its emitter, Lorentz rescaling may not be necessary—and a **reduced or null time dilation** could be observed.

7.2.1.6 Why This Matters

If a difference is observed, it would support the core claim of this book: that time dilation arises not simply from velocity, but from the **appearance of motion as detached from its source**. It would imply that Lorentz transformations are not just velocity-based but tied to deeper **kinematic relationships** between emitter and object. This would challenge the standard

assumption that all motion at velocity v demands equal time rescaling.

8 INTERPRETATIONS SUMMARY

This chapter brings together the core ideas developed throughout this book and offers a concise comparison between the standard interpretation of relativity and the alternative perspective explored here. The goal is not to challenge the mathematical structure of special or general relativity—indeed, the predictive success of Lorentz transformations and the Einstein Field Equations remains fully intact. Rather, this work reexamines how those equations are interpreted, and what we believe they imply about the nature of time, space, gravity, and motion.

Before proceeding, it is important to clarify what is meant in this book by "mathematical adjustments." These are not corrections in the sense of fixing errors, nor are they mere conveniences or hypothetical quantities. They are real, physically grounded recalibrations of how measurements in one frame relate to those in another—particularly in situations where an object's motion appears detached from the motion of its source. Such adjustments arise because our mathematical framework must maintain consistency with what is observed, especially when dealing with phenomena like the invariant speed of light or the near-light-speed behavior of massive particles. These adjustments yield accurate and measurable predictions, but they do not imply that time or space itself is physically altered.

- spacetime

At the heart of this reinterpretation lies a key distinction: **between mathematical adjustment and physical**

deformation. The standard view often treats time dilation, spacetime curvature, and gravitational phenomena as consequences of a physically malleable spacetime fabric. By contrast, the approach taken here views many of these same phenomena as real, measurable effects that arise from changes in energy, motion, and gravitational interaction—but without requiring us to treat time or space as physically deformable. Instead, they are expressed and organized through a geometric framework (the spacetime), which serves as a mathematical map rather than a physical medium.

To further clarify this distinction, in my interpretation, geometry is the mathematical structure we use to describe motion, acceleration, and gravitational behavior. It is a representational framework—not a physical substance that stretches or warps. The **physical elements** lie in mass, energy, acceleration, and gravitational effects, while the **geometry** provides the descriptive language used to organize their relationships.

Consider a *region* of flat spacetime. In this framework, flatness corresponds to a state where no mass or energy is present, and therefore, no gravitational field or acceleration exists. Objects in this region (the flat spacetime) either remain at rest or move at constant velocity relative to each other. Because there is no gravitational interaction altering their motion, the acceleration structure is uniform—effectively nonexistent. Geometry in this case is flat, not because of what space "is," but because there is **no variation in acceleration to represent**.

Now let us introduce a stationary mass—such as a planet—into that flat spacetime. In standard general relativity, we would say the mass creates a dent in spacetime curvature. In my interpretation, the dent signifies something else: it reflects the **pattern of acceleration** that arises in the presence of mass. The geometry becomes curved, not because space is bending, but because objects near the mass experience real, measurable acceleration that must be represented in the structure of the geometry. These objects no longer move uniformly—they accelerate toward the mass. What we call "spacetime curvature" is thus a **map of non-uniform acceleration**, not a deformation of a physical substance.

Now imagine the mass begins to move. The "dent" shifts accordingly, because the acceleration pattern is no longer stationary. The gravitational field evolves, and the geometry updates to reflect the new configuration. From this perspective, moving curvature is not a ripple in a physical fabric, but a mathematical representation of how the gravitational field—defined by acceleration—changes as mass and energy relocate.

This interpretation is anchored in the original insight that led Einstein toward general relativity: the **equivalence principle**. That principle revealed a profound link between gravity and acceleration—stating that locally, the effects of gravity are indistinguishable from those of acceleration. At the time, Einstein formulated this principle in physical, not geometric, terms. To express it mathematically, he and others developed a geometric model capable of describing how acceleration varies across space and time. Yet in the final form of the Einstein Field Equations, acceleration no longer appears

explicitly. The equations relate spacetime curvature to mass and energy, **but the concept of acceleration is now encoded within the geometry itself**. As a result, many readers encounter the final form—rich with references to spacetime, gravity, mass, and energy—but lose sight of **acceleration**, which was central to the original insight. **Over time, the geometry has been reinterpreted not as a map of acceleration, but as a literal, physical entity**.

In all of the aforementioned scenarios—whether the geometry is flat, static, or shifting—it functions as a **descriptive structure** used to organize acceleration, motion, and gravitational relationships. It enables precise predictions and mathematical coherence, but it does not imply that space or time itself is being stretched or bent. The Einstein Field Equations remain valid, but they are understood here as statements about **how physical content gives rise to patterns of acceleration**, not about how matter distorts a physical backdrop.

- Lorentz transformation

The Lorentz transformation was originally developed to describe the behavior of **light**—a massless entity that always travels at the same speed, regardless of the motion of its source. Because light does not inherit the momentum of its source; its velocity entirely detached from any emitting source. To maintain consistency between observers in different inertial frames, physicists introduced a transformation that mathematically adjusts space and time coordinates across those frames. These adjustments are not arbitrary—they reflect a real

need to reconcile observations considering a **source-independent** behavior. In my interpretation, the transformation serves as a tool to model that detachment, not as evidence that time slows or space contracts in any physical sense.

- Massive objects

This same logic extends to **massive particles** moving at extremely high speeds. When objects such as protons or muons are accelerated to velocities approaching that of light, their final speeds become increasingly **insensitive to the motion of the source** that produced them. Their motion begins to resemble that of photons—not in their physical makeup, but in their kinematic behavior. To elaborate more, their velocity increasingly appears independent from the velocity of their origin, and their behavior demands a mathematical transformation to ensure that observers in different frames report consistent physical descriptions. Lorentz transformations still apply—not because time or space are physically changing, but because we need to adjust our coordinates to keep track of motion that no longer follows the usual connection to the velocity of its source.

- experiments

This reinterpretation applies directly to high-speed experiments, including muon lifetime extensions, lithium-ion clock comparisons, and particle accelerators. In each case, the results are real and measurable, but they do not require us to imagine time itself stretching. Instead, they demonstrate that when a system's velocity becomes **observationally**

independent of its source, we must transform our mathematical framework to keep physical laws coherent across frames. The transformation is real in its predictive success—but it is mathematical in nature, not metaphysical.

A similar line of reasoning applies in **gravitational contexts**. When a signal originates from a region of lower or higher gravitational potential, its frequency may appear redshifted or blueshifted to a distant observer. In the standard view, this is attributed to time flowing more slowly or quickly depending on one's position within a curved spacetime. But in this interpretation, the shift is understood as a **real change in energy** that results from the gravitational field acting on the signal. Time itself has not changed; rather, the signal has interacted with a gravitational potential that alters how its frequency is expressed in another frame. Again, the mathematics of general relativity remains valid, but the interpretation shifts: the effect arises from **field interaction**, not from deformed time.

This reinterpretation also repositions how we understand phenomena such as **starlight bending** and **orbital decay**. When light bends near a massive object, it is not because space itself is curved in a physical sense, but because the gravitational field redirects the trajectory of the photon through a real, physical interaction. The deflection is measurable, but it reflects a change in momentum—not a change in the underlying structure of space. Similarly, when binary systems lose energy and spiral inward over time, the standard interpretation views this as the result of gravitational waves propagating through spacetime. But in this framework, orbital decay is treated as a

consequence of **energy loss through a gravitational field**—a dynamic interaction between matter and its environment, not a ripple moving through a deformable medium.

This same shift in perspective applies to **mass and energy inference** in relativistic astrophysics. In the standard view, the curvature of spacetime—shaped by mass—alters the timing of signals and the motion of objects, allowing scientists to infer the distribution of unseen mass. In this interpretation, the same observations are explained by **how the gravitational field affects energy and acceleration**, without invoking curvature as a physical entity. When orbital inclination affects pulse timing, it does so by altering how signals interact with the field along our line of sight—not by changing the way light navigates a warped geometry.

In all of these cases—whether dealing with high-speed particles, gravitational redshift, or light deflection—the underlying principle is the same: **the mathematics remains accurate, but the meaning shifts**. Time and space are not physically stretched, compressed, or twisted. Rather, the geometry serves as a **coordinate model** of relationships among acceleration, energy, and motion. The effects we observe are real. The equations that predict them are valid. But what those equations describe is **not a mutable spacetime fabric**, but the structure of interaction—how systems evolve in relation to energy and acceleration.

- closing

This interpretation brings us full circle to Einstein's original insight. The equivalence principle revealed that **acceleration**

and gravity are intimately connected, and that connection opened the path to a geometric description of gravitational behavior. But as the theory evolved, acceleration became embedded in the geometry, and eventually **forgotten as a physical quantity**. This work recovers it—not by rewriting the equations, but by returning to their conceptual roots. Geometry is kept, but interpreted as a map. The physics is preserved, but reframed. And spacetime, once a metaphor for motion and interaction, is restored to its original role: a structured mathematical language for describing **how physical systems move, accelerate, and interact** in a gravitational world.

9 REFERENCES

[1] K. J. Treschman, "Recent astronomical tests of general relativity," *International Journal of Physical Sciences*, vol. 10, no. 2, pp. 90–105, 2015.

[2] A. Einstein, "On the Electrodynamics of Moving Bodies," *Ann Phys*, vol. 17, pp. 891–921, 1905.

[3] H. A. Lorentz, "electromagnetic phenomena in a system moving with any velocity smaller than that of light," *Academy of Sciences of Amsterdam*, vol. 6, pp. 809–831, 1904.

[4] J. McKelvie, "Revisiting the matter of time dilation in special relativity," *Journal of Physics & Optics Sciences*, vol. 6, no. 6, pp. 1–7, 2024.

[5] J. Wambsganss, *Gravitational Lensing: Strong, Weak and Micro-Saas-fee Advanced Course 33*. Springer-verlag Berlin And Hei, 2010.

[6] C. W. Misner, K. S. Thorne, and J. A. Wheeler, *Gravitation*. Macmillan, 1973.

[7] T. Damour and N. Deruelle, "General relativistic celestial mechanics of binary systems. II. The post-Newtonian timing formula," in *Annales de l'IHP Physique théorique*, 1986, pp. 263–292.

[8] R. ~D. Reasenberg *et al.*, "Viking relativity experiment - Verification of signal retardation by solar gravity," vol. 234, pp. L219–L221, Dec. 1979, doi: 10.1086/183144.

[9] N. Ashby, "Relativity in the Global Positioning System," *Living Rev Relativ*, vol. 6, no. 1, p. 1, 2003, doi: 10.12942/lrr-2003-1.

[10] M. Kramer *et al.*, "Tests of general relativity from timing the double pulsar," *Science (1979)*, vol. 314, no. 5796, pp. 97–102, 2006.

[11] S. Reinhardt *et al.*, "Test of relativistic time dilation with fast optical atomic clocks at different velocities," *Nat Phys*, vol. 3, no. 12, pp. 861–864, 2007, doi: 10.1038/nphys778.

[12] R. Grieser *et al.*, "A test of special relativity with stored lithium ions," *Applied Physics B*, vol. 59, no. 2, pp. 127–133, 1994, doi: 10.1007/BF01081163.

[13] J. Bailey *et al.*, "Measurements of relativistic time dilatation for positive and negative muons in a circular orbit," *Nature*, vol. 268, no. 5618, pp. 301–305, 1977, doi: 10.1038/268301a0.

[14] J. C. Hafele and R. E. Keating, "Around-the-World Atomic Clocks: Observed Relativistic Time Gains," *Science (1979)*, vol. 177, no. 4044, pp. 168–170, Jul. 1972, doi: 10.1126/science.177.4044.168.

[15] J. C. Hafele and R. E. Keating, "Around-the-World Atomic Clocks: Predicted Relativistic Time Gains," *Science (1979)*, vol. 177, no. 4044, pp. 166–168, Jul. 1972, doi: 10.1126/science.177.4044.166.

[16] W. A. Rodrigues and E. C. de Oliveira, "A comment on the twin paradox and the Hafele-Keating experiment," *Phys Lett A*, vol. 140, no. 9, pp. 479–484, 1989, doi: https://doi.org/10.1016/0375-9601(89)90126-6.

[17] G. B. Malykin, "Method for Experimental Verification of the Effect of Gravitational Time Dilation by Using an Active Hydrogen Maser," *Radiophysics and Quantum Electronics*, vol. 58, no. 4, pp. 290–295, 2015, doi: 10.1007/s11141-015-9603-4.

[18] R. F. C. Vessot *et al.*, "Test of Relativistic Gravitation with a Space-Borne Hydrogen Maser," *Phys Rev Lett*, vol. 45, no. 26, pp. 2081–2084, Dec. 1980, doi: 10.1103/PhysRevLett.45.2081.

[19] R. V Pound, "ON THE WEIGHT OF PHOTONS," *Soviet Physics Uspekhi*, vol. 3, no. 6, p. 875, 1961, doi: 10.1070/PU1961v003n06ABEH003295.

[20] R. V Pound and G. A. Rebka, "Apparent Weight of Photons," *Phys Rev Lett*, vol. 4, no. 7, pp. 337–341, Apr. 1960, doi: 10.1103/PhysRevLett.4.337.